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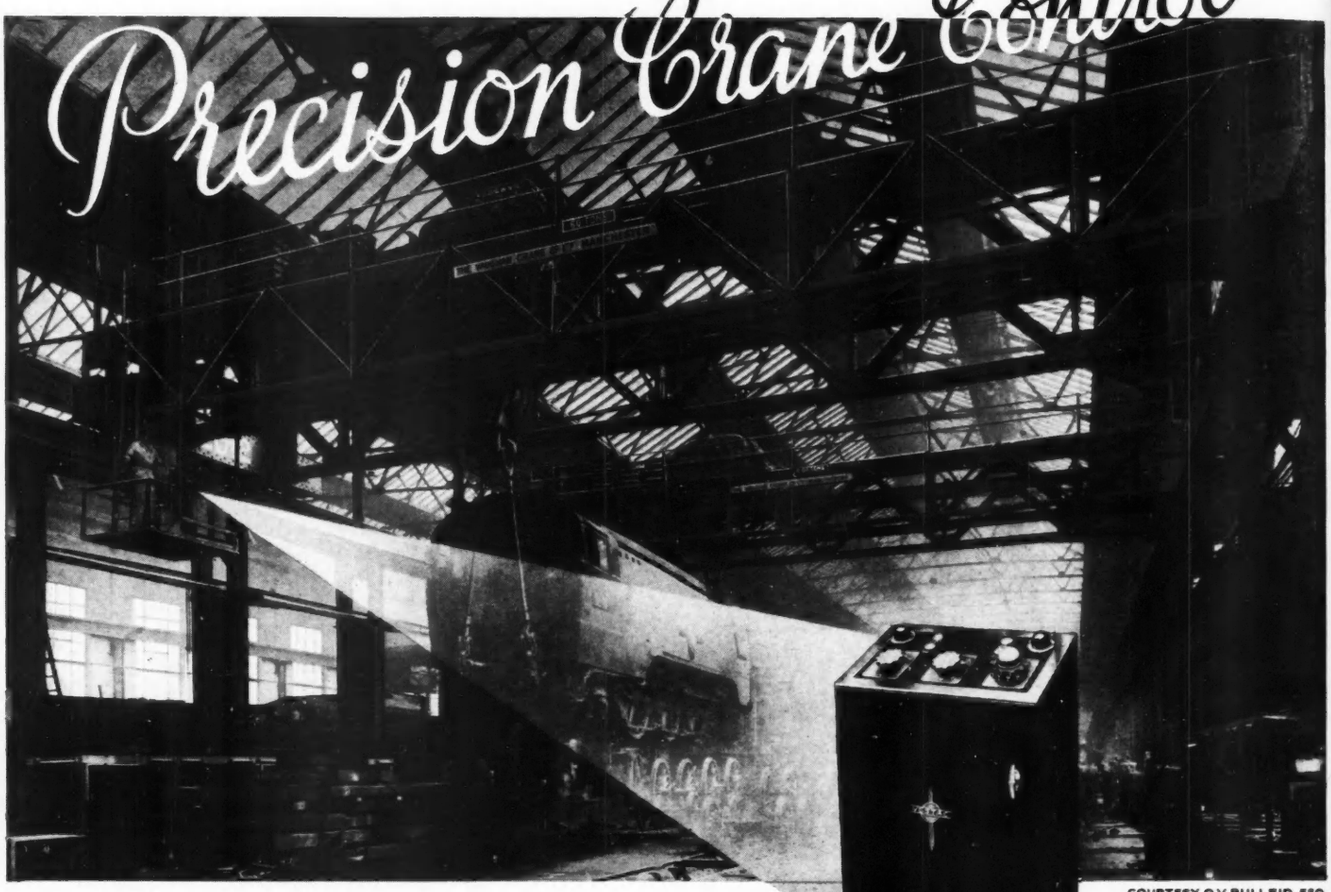

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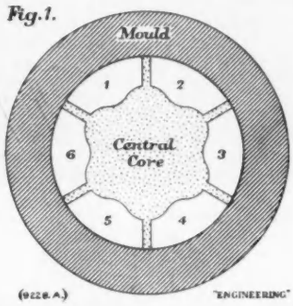
CENTRIFUGAL AND PRECISION STEEL CASTINGS FOR AIRCRAFT.

By J. F. B. JACKSON, B.Sc., A.R.I.C.

THE application of centrifugal casting to the manufacture of pipes and similar cylindrical parts is well known, and in making such castings a mould of cylindrical form is rotated about its own axis, the axis normally being either horizontal or slightly inclined to the horizontal. Castings produced centrifugally in this way are generally described as having been produced by horizontal-axis, as opposed to vertical-axis, centrifugal casting, and the internal contour of the pipes or sleeves so produced is formed under centrifugal action alone, there being no supporting internal core or mould component. It will also be appreciated that horizontal-axis centrifugal casting lends itself particularly well to the production of parts which are great in length and relatively small in diameter, such as aircraft-engine cylinder liners or sleeves. These were produced in this way in large numbers during the recent war. Where the converse dimensions apply, namely, where a ring casting of relatively large diameter but small length is to be produced, there is an advantage in rotating the mould about a vertical axis.

Fig. 1.



By employing a vertical-axis mould it is possible to introduce an internal refractory core which serves three main purposes. In the first place, it overcomes the tendency of the molten metal to form a parabolic internal contour; secondly, it restricts the amount of metal which can enter the rotating mould; and thirdly, it imparts any desired contour to the internal face of the casting. The introduction of the central refractory core can be extended in principle so that by the addition of radial partition cores the annular mould cavity becomes subdivided and a number of individual castings can be produced, as shown in Fig. 1, on this page. In this way metal may be fed centrifugally into a series of mould cavities distributed circumferentially within a parent mould under conditions which, in principle, are directly related to orthodox centrifugal casting. A further stage in the evolution is for each of these mould cavities to be modified in contour in such a way that completely irregular and asymmetrical castings are produced. The use of a central core in a vertical-axis mould and the production of asymmetrical centrifugal castings following the principles just described are frequently referred to in America as being "semi-centrifugal" and "centrifuging" methods, respectively. This American terminology is regarded as being misleading in so far as the terms semi-centrifugal and centrifuging suggest some radical departure from centrifugal casting in its more elementary, or, as the Americans say, in its "true" form.

There are, however, two main points of difference and of metallurgical importance between the production centrifugally of asymmetrical castings and of plain rings or sleeves, and these points must not be overlooked. In the first place, whereas in horizontal-axis casting as previously described, and as in the case of vertical-axis production in its simplest form using steel moulds, progressive freezing normally takes place from the periphery towards the centre, it is possible, in the last described variation of centrifugal casting, that is, in the production of irregularly-shaped castings clustered round a central feeding point, for freezing to take place in a number of directions simultaneously. Secondly, by reducing the effective circumference of a centrifugal mould the rate at which the remaining mould cavities will be filled by molten metal will be substantially increased.

Clearly, by reducing the teeming rate from the ladle into the parent mould this last effect will be lessened but, in practice, it is found that there is a resultant distinct increase in mould-filling rate radially from the periphery towards the axis of rotation in the cluster type of mould as distinct from the continuous-ring mould. This additional factor decreases the rate of heat abstraction from the molten metal in the mould cavity and must inevitably exert its influence upon the freezing process. These two major differences between vertical-axis casting of complex parts and either vertical or horizontal axis production of simple ring castings requires emphasis, together with the fact that in the "cluster" mould a sand or refractory mould material of relatively low thermal conductivity is generally employed in place of a metal mould of obviously very much greater thermal conductivity. Nevertheless, it has been established that a degree of directional freezing not obtainable under static casting conditions does arise in vertical-axis cluster casting and as a result of this the degree of soundness in the castings so produced has fully warranted the development and application of the process.

In 1943, a foundry unit was laid down by Messrs. David Brown and Sons (Huddersfield), Limited, at Penistone, near Sheffield, for the application of

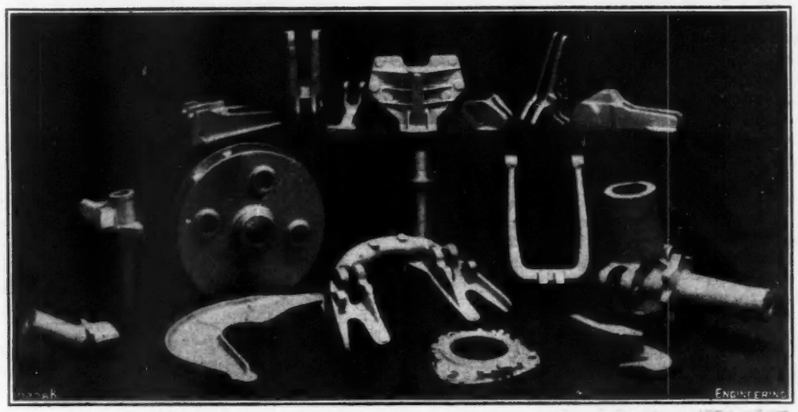


FIG. 2. CENTRIFUGALLY-CAST ASYMMETRICAL CASTINGS.

FIG. 3. SLOW COOLING OF MOULDS.

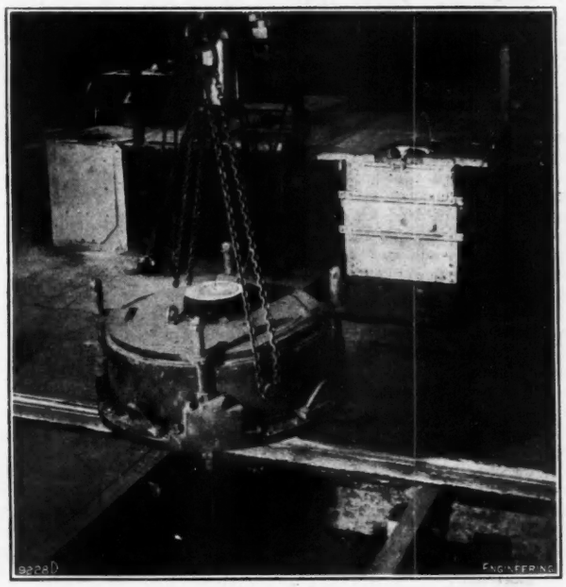


FIG. 4. LOWERING MOULD ON TO CASTING MACHINE.

vertical-axis centrifugal casting to the production of aircraft-quality high-tensile alloy steel, and while it was known that such production must necessarily involve what are clearly foundry operations, the control of these and the selection of the operators were based essentially on what may be termed "laboratory" standards. At all stages of the production process, steps were taken to ensure that any rational control that would ensure consistency of treatment and adherence to established technique was introduced and applied. By this it is not suggested that any completely revolutionary controls were introduced, but rather that a system of stage by stage checking was applied to an extent not normal, and certainly not commercially possible, in the average steel foundry. Very many different types of aircraft components have been produced successfully in high-tensile steel as vertical-axis centrifugal castings, some of which are shown in Fig. 2, on page 481.

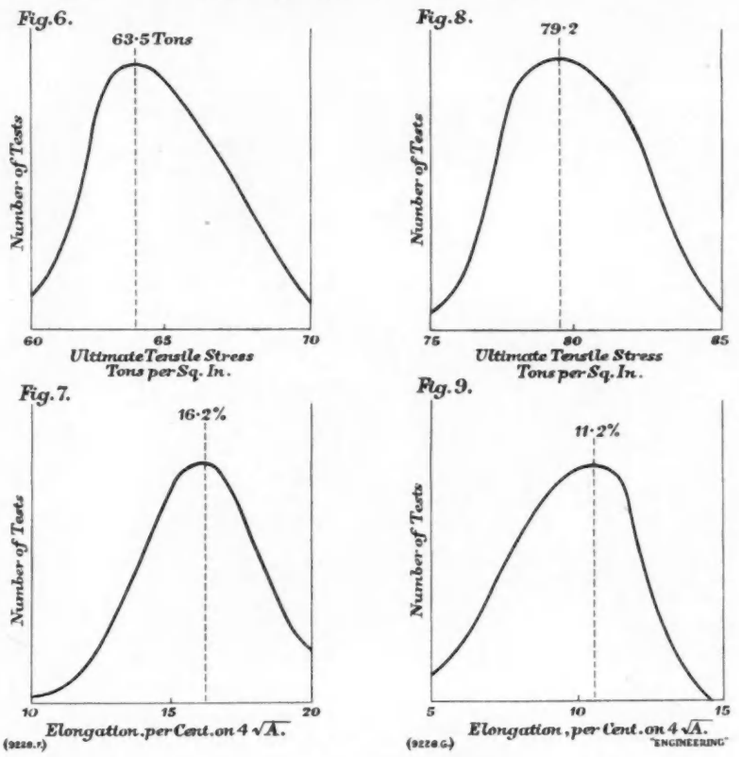
When the manufacture of centrifugal steel castings for aircraft was in its infancy, relatively long periods, of perhaps six months up to 12 months, were frequently required to evolve the necessary casting technique. It is now seldom that more than a few weeks are required for this purpose and sample castings to any new type are usually available within two to three months. This "development period" in relation to the manufacture of any new type of casting has been mentioned as its importance is regarded as being fundamental to the whole technical approach to this field of steel-casting production. In passing, we might well draw a parallel between this development period and that, for instance, which is to be expected in relation to the aircraft, or the aircraft engine, itself into which the casting may later be fitted. No aircraft engineer is expected to be able to design an aircraft, or its engine, in such a way that it is perfect in all details as originally proceeding from the drawing board. The solution of many stress problems can be effected only by trial and error on the test bed and by intelligent adjustment subsequently: so it is with the production of an aircraft steel casting. As soon as a satisfactory foundry technique has been evolved for any particular casting, details of this technique are carefully recorded for future reference, and any modifications introduced during production are likewise entered on the appropriate "technique" or "methods" drawing.

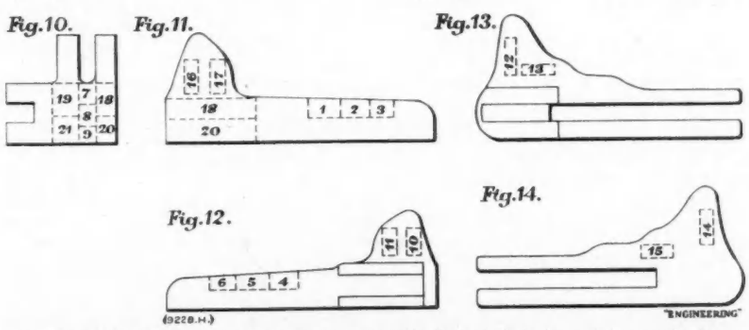
The establishment of a satisfactory mould layout for any casting depends obviously upon a number of practical and economic considerations regarding mould size, number of castings per mould, and so on, but all these are governed essentially by the metallurgical requirements of the casting itself. In evolving a mould layout, therefore, castings produced during the development period are most carefully examined for both surface defects and internal unsoundness, and mould layout is repeatedly adjusted until the required standards are satisfied. The actual methods of inspection during the development period are essentially the same as in subsequent production but they are obviously more intensively applied during the preliminary stages.

Referring now briefly to the foundry operations themselves; the first step is to prepare the necessary pattern equipment for the mould-making operation. The moulds themselves are normally made from an orthodox linseed oil-bonded silica sand which is prepared carefully to a standard composition, and repeated tests are performed to ensure uniformity of properties. The core stoves are controlled with regard to rate of travel and to temperature, the latter being automatically recorded. After baking, the moulds are allowed to cool slowly, as shown in Fig. 3, on page 481, and they are then given a coating of refractory paint on those surfaces that come into contact with the molten steel. All these operations are in accordance with orthodox foundry practice. Before being assembled for casting purposes, the moulds are passed under a battery of infra-red electric lamps to ensure that all traces of moisture have been removed. If this were not done there would be a danger of blowhole formation, which, though of course detected by X-ray inspection at a later stage, would result in rejection of the casting. The mould parts are then assembled in steel boxes of special design preparatory to being fitted into the centrifugal-casting units. Fig. 4, on page 481, shows a mould being lowered on to a casting machine of patented design, to which it is automatically locked during rotation and released afterwards. The casting machines are controlled for speed of rotation and fitted with indicating revolution counters.

CENTRIFUGAL CASTINGS FOR AIRCRAFT.

FIG. 5. ANNEALING FURNACE FOR CASTINGS.





CENTRIFUGAL CASTINGS FOR AIRCRAFT.

FIG. 15. TEST TO DESTRUCTION OF HIGH-TENSILE STEEL CASTING.

FIG. 17. BRISTOL "THESEUS" OUTER CASING.

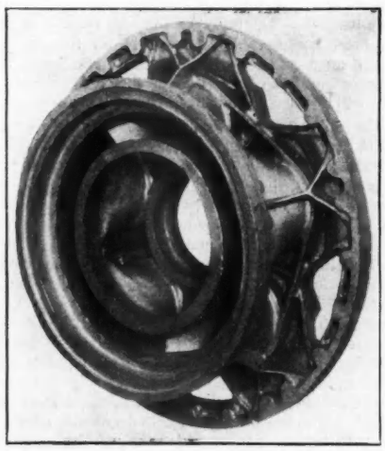


FIG. 16. NAPIER "NAIAD" MANIFOLD CASING.

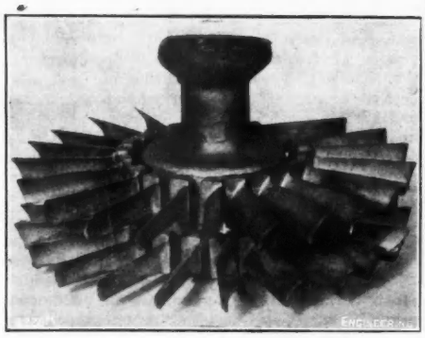


FIG. 18. BATCH OF GAS-TURBINE BLADE CASTINGS.

Speed of rotation is regarded as being of importance from the point of view of inducing directional solidification and of causing the molten metal to run through thin sections, but, in general, it is kept as low as possible consistent with satisfactory results. In practice, vertical-axis centrifugal casting permits considerably greater latitude in relation to speed of rotation than is the case when casting about a horizontal axis for reasons previously indicated, and as a matter of interest it may be said that in the vertical process a mean peripheral velocity of the order of 750 ft. per minute is generally observed. This corresponds, for instance, to a rotational velocity of the order of 100 revolutions per minute for a mould of some 3 ft. in diameter. In horizontal-axis centrifugal casting it is normal practice to employ peripheral speeds of the order of 1,250 ft. to 1,500 ft. per minute.

Steel is melted in small acid-lined high-frequency electric furnaces, the temperature being controlled by immersion thermocouples. The metal charged into these furnaces is specially refined and ingoted from a 10-ton basic electric-arc furnace plant. In practice, low- or medium-carbon low-alloy content ingots of known high quality are re-melted and any alloys necessary are then added. Deoxidation is by calcium in the form of calcium-manganese-silicon alloy, added at the rate of 4 lb. a ton, followed by, or together with, an aluminium addition corresponding to 2 lb. a ton of steel. It is preferred, in other words, to perform a major deoxidation process by calcium and to add a minimum of aluminium, compatible with sound casting production.

After removal from the mould the castings are successively annealed, flame cut by oxy-acetylene to remove unwanted runners and feeding heads, surface ground and then heat treated. Fig. 5, opposite, shows a 100-kW continuous electric-resistance furnace in which the low-alloy aircraft steel castings are annealed, usually at a temperature of 925 deg. C. for a period of four hours in the furnace. They are cooled in air from the annealing temperature. The same furnace is used for hardening treatments, oil and water quenching tanks being available for this purpose. The quenching liquids are circulated from large tanks, bulk of liquid rather than cooling mechanism being relied upon to avoid excessive rise in temperature, which is indicated by a dial thermometer on each quenching tank. Tempering is performed in 60-kW vertical forced air-circulation electric furnaces, and is normally conducted in two stages, each of about four hours minimum. It has been shown that repeated tempering tends to give better mechanical properties than a single continuous temper, and, moreover, the control of heat-treatment conditions is more precise by following such a procedure. After the first temper the castings are subjected to Brinell testing and the temperature and duration of the second temper are then adjusted to give final properties within relatively fine limits.

As a final inspection procedure, for specification purposes, all high-tensile steel castings intended for aircraft are examined by radiographic methods and inspected for flaws by the electromagnetic process. Both these non-destructive testing methods, however, are also first applied relatively early in manufacture, so that any castings having major defects can be "weeded out" before expensive heat treatment and fettling operations have been performed upon them. Each casting made is given an individual identification immediately it is cast, this identification having reference to the furnace heat and even, in some cases, to the position in the mould at the time of casting. This identification number is preserved throughout the subsequent history of the casting until it finally passes all tests and is issued to the aircraft constructor. In view of the abnormal standards of soundness and surface perfection stipulated, it is not unusual for some castings to be rejected at one or other stage of inspection. Those not accepted for dimensional or other reasons which do not affect the mechanical properties, are frequently employed for test purposes; that is to say, test pieces are removed from them for mechanical testing and for official Air Ministry quality-control purposes.

The Air Ministry D.T.D. Specifications, Nos. 666 and 705, covering the production and inspection of high-tensile steel castings such as are now widely used for air-frame parts, lay particular emphasis upon the degree of control at all stages during manufacture. The first clause of the specifications demands, in fact, that any foundry wishing to produce castings to these specifications must have technical approval from the appropriate Ministry department before being permitted to do so. Such approval, apart from requiring evidence regarding the firm's capabilities from the point of view of equipment and personnel, may go so far as to require the submission of relatively large numbers of complete castings for statistical mechanical-testing purposes. In passing, it is of interest to note that, based upon the statistical examination of steel castings in this way, it has been found possible to permit the stressing of certain high-tensile aircraft castings to a limit directly comparable with that which would be applied in the case of corresponding steel forgings.

TABLE I.—*High-Tensile Steel Castings for Aircraft: Typical Compositions.*

Element.	1 per cent. Chromium-Molybdenum.	2 per cent. Nickel-Chromium-Molybdenum.
	Per cent.	Per cent.
Carbon	0·22–0·32	0·22–0·32
Silicon	0·30–0·50	0·30–0·50
Sulphur	0·020 maximum	0·020 maximum
Phosphorus	0·020 maximum	0·020 maximum
Manganese	0·40–0·75	0·50–0·80
Nickel	0·5 – 0·7	1·75–2·25
Chromium	0·9 –1·20	0·8 –1·2
Molybdenum	0·15–0·35	0·30–0·40
Vanadium	Nil	Nil

TABLE II.—*High-Tensile Steel Castings for Aircraft: Specified Minimum Mechanical Properties.*

Test.	D.T.D.666 Specification.	D.T.D.705 Specification (Tentative).
0·1 per cent. proof stress, tons per sq. in.	45	60
Ultimate stress, tons per sq. in.	60	75–83
Elongation, per cent. on $4\sqrt{A}$.	12	7
Reduction of area, per cent.	30	14
Izod, ... ft. lb.	30	10

In the foundry with which the author is associated, two normal compositions of low-alloy steel are generally employed, the first a 1 per cent. chromium-nickel-molybdenum and the second a 2 per cent. nickel-chromium-molybdenum steel. These steels were finally selected as standard after extended investigations into the casting properties of a number of compositions. The choice between the two steels is generally determined by the ruling section of the casting in question and by the tensile properties required. Table I gives details of the chemical composition of the two steels, while Table II gives the minimum mechanical properties stipulated in Specifications D.T.D. 666 and 705. Table III

indicates the dividing line with regard to application, based upon comparable hardenability and the maintenance of ductility in heavy sections. Figs. 6 to 9, on page 482, give an indication of the mechanical properties obtained over a large number of tests upon both types of alloy steel. Figs. 6 and 7 are frequency curves showing the mechanical properties of 1 per cent. chromium-nickel-molybdenum cast steel (Specification D.T.D.) 666; and Figs. 8 and 9 are corresponding curves for 2 per cent. nickel-chromium-molybdenum cast steel (Specification D.T.D. 705). An interesting comparison between these frequency curves and the specification requirements quoted in Table II can be made. It must be understood that the mechanical properties refer to those given by the castings themselves and not by separately cast test pieces of ideal form. Figs. 10 to 14, on page 482, show a typical wing-hinge fitting casting and the positions from which test pieces were taken by one of the leading aircraft manufacturers. Table IV gives details of mechanical test results shown by the various test pieces. Fig. 15, on page 483, illustrates another type of casting, tested to destruction, and attention is drawn to the evidently ductile fracture obtained

TABLE III.—*High-Tensile Steel Castings for Aircraft: Maximum Permissible Ruling Sections.*

Steel.	Nominal Ultimate Stress.	Permissible Ruling Section.
	Tons per sq. in.	In.
1 per cent. chromium-nickel-molybdenum	65	2·00
	75	1·25
2 per cent. nickel-chromium-molybdenum	65	4·00
	75	3·25
	85	2·50

TABLE IV.—*Mechanical Tests on Wing-Hinge Fitting. Casting* E1855–4D.

Position.	0·1 Per Cent. Proof Stress, Tons per Sq. in.	Ultimate Stress, Tons per Sq. in.	Elongation, Per cent.	Reduction of Area, Per cent.	Izod, Ft. lb.
1	58·1	65·5	21·8	62·0	—
2	—	—	—	—	44
3	61·0	65·5	22·7	63·7	—
4	—	—	—	—	38
5	65·6	64·2	12·0	30·5	—
6	—	—	—	—	36
7	55·8	64·2	11·0	29·0	—
8	50·5	59·5	8·0	20·2	—
9	58·7	65·5	15·0	43·1	—
10	60·4	66·5	13·0	28·3	—
11	60·0	66·0	12·0	37·8	—
12	60·0	66·2	12·0	36·0	—

at 60/70 tons per square inch ultimate tensile stress (D.T.D. 666 Specification). It should be understood that this procedure of cutting up castings and of taking tests from a series of test pieces from the castings is normal practice, and, in fact, a mandatory requirement on any new casting made under this D.T.D. Specification. It is, of course, one of the main inspection operations applied during the development period.

Tests have been made by another well-known aircraft firm to determine the fatigue properties of centrifugal steel castings, and they report that when working to D.T.D. 666 (namely, 60 tons per square inch minimum ultimate stress) castings exhibit properties equivalent to the transverse properties of a corresponding forged steel (such as given in Specification S.11). In other words, a fatigue-stress limit of the order of 40 to 42 per cent. of the ultimate tensile stress is given. Although tests to date are not conclusive, there is evidence to show that, in a fatigue test, cast steel is much less sensitive to notch effect than the forged material. It may be relevant to note, at this point, that, at equivalent hardness levels, the high-tensile cast steels are reported to be measurably more machinable than the forged equivalent. It is felt that such free-cutting characteristics and low notch sensitivity with regard to fatigue resistance may have some inherent connection.

While, undoubtedly, a very considerable degree of success has been achieved in the production of this type of casting to meet aircraft requirements, it would be misleading to infer that no scope remains for improvement. As in the production of steel forgings there are, in fact, many problems of steel-making, of heat treatment, and of freezing-process control that are far from understood, all of which may exert a vital influence on the quality of the resultant casting. Metallurgical and foundry research must continue therefore in this field with the long-term object of meeting the increasing demands that will inevitably be made by the aircraft engineer.

The advent of the jet and gas-turbine engines, apart from involving some of the most difficult metallurgical problems that are being faced at the present time, has introduced a requirement for large castings of extremely complex design suitable for relatively high-temperature service. Figs. 16 and 17, on page 483, may be regarded as typical parts which have been produced as centrifugal castings in heat-resisting steel. Fig. 16 shows a Napier "Naiad" manifold casing, and Fig. 17 a Bristol "Theseus" outer casing. It will be noticed that relatively light sections are involved in all the castings shown and the use of centrifugal-casting technique has assisted very considerably the practical difficulties with which these sections are associated. The metallurgical requirements of such components are of interest in so far as the temperature of operation is in the region of 650 deg. to 800 deg. C. In this connection, and owing to the fact that stresses generally are not particularly high, the dimensional stability, gas tightness, resistance to scaling, and even the machinability, are normally of greater relative importance than the creep properties. Under the heading of dimensional stability, both the expansion characteristics and the resistance to distortion, under repeated temperature cycles and frequently under complex thermal gradients, may be considered. It is safe to say that both these characteristics can be regarded as being of vital importance.

The coefficient of expansion of the material may not necessarily be required to be small, as the components in question may be attached directly or otherwise to light-alloy parts of relatively high expansion. In this case a number of the well-known austenitic alloys, such as either columbium-bearing 18 : 8 chromium-nickel, or, more frequently, 25 : 12 : 3 chromium-nickel-tungsten alloy, have been shown to be suitable. Where a low expansion coefficient is necessary, and, if temperature conditions permit, one of the ferritic steels may be chosen, or even a high-nickel alloy of the Invar-type, which, of course, can give a mean coefficient as low as $0{\cdot}8 \times 10^{-6}$ in. per inch per degree over a range of some 500 deg. C. With regard to resistance to distortion in service, the centrifugally-cast parts described have been shown to have, as might be expected, a definite advantage in practice over composite welded structures. For proof of pressure tightness, castings of the type in question are subject, before acceptance, to X- or gamma-ray radiography and to surface inspection either by the electromagnetic or the fluorescent methods. Machinability has been considerably improved by the suitable adjustment of the sulphur content, without apparent detriment to other important properties.

Of all recent casting developments, the application of the age-old principles of "lost-wax" moulding to the production of accurately-formed engineering parts, has drawn special attention. The fact that many of the so-called precision castings produced by this process have been for jet-engine construction has enhanced the interest taken in the matter. It will be known generally that the process involves essentially the use of wax patterns which are embedded in a refractory mould or investment material and are subsequently melted away to leave a jointless mould cavity which can be of high dimensional accuracy. Instead of wax, low melting point alloys and even "frozen" mercury have been employed for the making of fusible patterns. Considerable skill is attached to the making of the dies from which the wax patterns are themselves produced. After assembly, the wax patterns are mounted in a metal container into which the mould material in fluid form is poured, and after solidification or "hardening" of the refractory, the wax pattern is melted out. To form the castings themselves, liquid metal is fed into the mould cavities under positive pressure, which may be brought about either by reducing the pressure in the mould, or, more commonly, by increasing it behind the liquid metal as it pours from the melting furnace. As a further alternative, pressure generated centrifugally has been employed for this purpose satisfactorily. The form of wax pattern assembly employed for centrifugal-casting purposes can be inferred from Fig. 18, on page 483, which illustrates a batch of centrifugal precision castings, in this case gas-turbine blades, before detachment from their main runner. The castings are subsequently shot-blasted and inspected dimensionally.

As applied to the high-melting point alloys the process is by no means the straightforward and trouble-free technique which published information seems to infer. Apart from its inherent production problems the process is expensive to operate and its satisfactory application commercially requires the full appreciation of all the factors involved. Experience in this country is generally to the effect that dimensional accuracy is possible to within some $\pm 0{\cdot}006$ in. on dimensions up to an inch or slightly more, depending upon the general contour of the part in question. Accuracy within $\pm 0{\cdot}002$ in., and even less, may be possible on small dimensions and when very large quantities of a particular component are in production. It is, however, beyond doubt that precision casting has an important future in relation to the development of the gas turbine, and any application involving metals for very high temperature service may ultimately require the use of precision-cast as distinct from forged alloys. It is safe to assume that as alloys of high creep resistance are developed they will necessarily be less and less forgeable and also probably less machinable, and the tendency to resort to casting as a means of forming parts from such alloys will be inevitable.

Until fairly recently, the development of alloys for high-temperature service has been governed very largely, as regard composition, by considerations of forging. The application of precision casting removes these restrictions and has enabled research to be undertaken upon alloys without paying particular attention to their forging properties. Casting properties have to be determined but the limitations likely to be imposed in this direction are not visualised as being serious. The potentialities of cast high-temperature alloys, at the present time, are very far from being realised, and in assessing recent developments in this field it must be recognised that we are merely at the outset of our investigations from a metallurgical point of view. By making use of alloys developed for forging purposes it has been shown that a casting can possess scale and creep-resisting properties directly comparable with those of the wrought alloy. Dimensional stability and resistance to thermal shock are known to be at least as good in the cast material, but in so far as fatigue at high temperatures is concerned the cast material is believed to be inherently inferior to the wrought for any given composition. It is in this direction, namely, in the development of a cast alloy having high resistance to fatigue and particularly to fatigue superimposed upon creep, that future important work would appear to lie. Unhampered by considerations of "forgeability" it is not unreasonable to suppose that marked metallurgical advances are likely to be made, and when these occur the employment of such alloys by the engineer will be made possible by the lost-wax precision casting process.

COAL PRODUCTION IN THE RUHR.—The output of coal in the Ruhr district of Germany totalled 7,150,000 tons in March of the present year, compared with 6,420,000 tons in February and 6,620,000 tons in January.

SUMMER SCHOOL IN PHYSICS.—As briefly announced on page 208, *ante*, a summer school on the "Physics of Solids, with Particular Application to the Properties of Ionic Solids" will be held in the H. H. Wills Physical Laboratory of the University of Bristol. The programme of the school has now been published, and this states that the course will commence at 2.15 p.m., on Wednesday, September 8, and end at 12.45 p.m. on Wednesday, September 15. The fee will be 8 guineas. Applications and inquiries should be addressed to Mr. W. E. Salt, O.B.E., M.A., B.Com., The University, Bristol, 8, and completed application forms should be returned before June 15.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

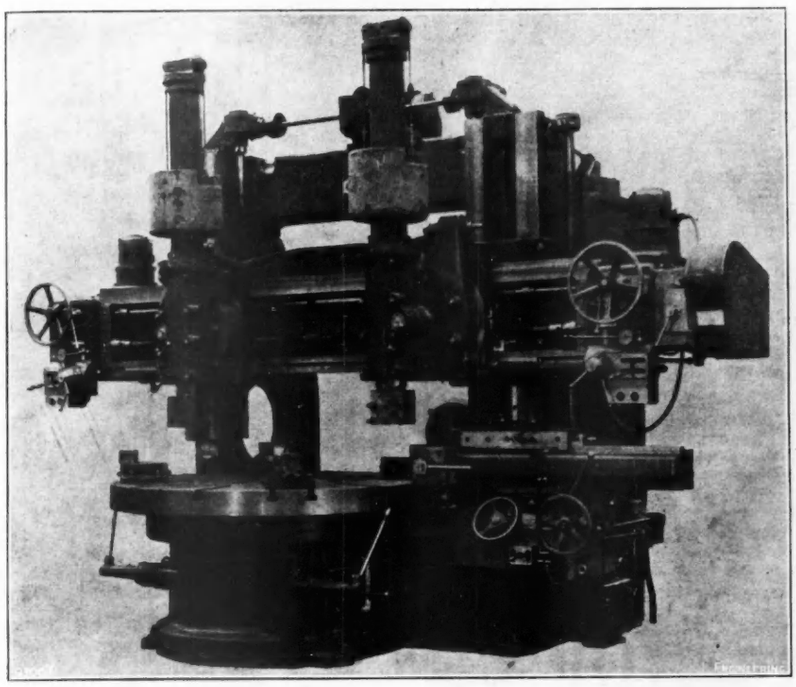


FIG. 24. 6-FT. BORING AND TURNING MILL; MESSRS. CRAVEN BROTHERS (MANCHESTER), LIMITED.

THE BRITISH INDUSTRIES FAIR.

(*Continued from page* 464.)

GENERALLY speaking, it appears that the British Industries Fair, which closed last Friday, May 14, was a success. Quantitative results cannot, of course, be known for some time if, in fact, they can ever be accurately assessed; but the attendance, reported as being slightly less than last year, made up in interest what it may have lacked in numbers. There was, moreover, a greater air of reality about the proceedings, since, in spite of rumours to the contrary, exhibitors were able to display more certainty both as regards delivery dates and prices. Further, no doubt could have been left in the minds of buyers of the ability of British manufacturers to produce high-quality goods in variety.

Continuing our account of the equipment shown at Birmingham, a heavy vertical boring and turning mill was exhibited on the stand of Messrs. Craven Brothers (Manchester), Limited, Vauxhall Works, Reddish, Stockport. This machine, which is illustrated in Fig. 24, on this page, is equipped with a table 6 ft. in diameter, and will accommodate work up to 6 ft. 3 in. in diameter and 4 ft. in height. The table is provided with four loose steel jaws, and is mounted on a spindle and a white-metal V-section annular way. The spindle and way are lubricated by filtered oil under pressure. The mill is driven by a 25-h.p. motor through a multi-plate friction clutch and a 12-speed gearbox, giving table speeds of from 1·5 to 30 r.p.m. There are two cross-slide saddles, each of which is fitted with an octagonal ram counterbalanced by a ring weight, as shown in Fig. 24. The saddles are provided with independent horizontal, vertical and angular self-acting feeds and rapid power adjustments. The slides can be swivelled to 30 deg. on each side of the vertical position. The right-hand saddle is arranged for taper turning by means of change gears between the horizontal and vertical feeds. A side turning head is mounted on the right-hand column and counterbalanced. It carries a square-section cast-iron ram with a four-position turret tool-head. Vertical and horizontal feeds are provided by an independent gearbox, and rapid adjusting movements can be made. The all-electrically operated motions are controlled by push buttons; and an interlocking arrangement ensures that oil is supplied to the principal bearings, etc., before the main motor can be started. The complete mill weighs about 26 tons.

Messrs. A. Reyrolle and Company, Limited, Hebburn, Co. Durham, were showing a selection of the metal-clad and open-type switchgear for which they are so well known, together with demonstration panels of their protective systems for feeders and 'bus bar zone protection. Typical of the switchgear is the 66-kV small oil volume open-type circuit breaker, the appearance of which is illustrated in Fig. 25, on page 486, while its construction will be clear from the cross-section reproduced in Fig. 26. As will be seen, this circuit breaker consists essentially of a lower portion *a*, which provides insulation from earth and support for the upper portion. The latter contains the circuit-breaker chamber *b*, which is a Bakelised-paper cylinder enclosed in a porcelain shed to provide protection against the weather. Above this, again, is a centrifugal separator *c*, which allows the gases generated on short-circuit to escape without loss of oil. A silica-gel breather and two oil-level indicators *d* are fitted on the outside. The oil in the circuit breaker is in two separate portions. That in the circuit-breaking chamber itself is used for arc-quenching, and therefore requires reconditioning after the clearance of short-circuits. The rest of the oil, which is contained in the lower portion, and in the space between the circuit-breaking chamber and the porcelain in the upper portion, is used for insulation only.

The arc-control device *e* is of the Reyrolle block turbulator type and, together with the upper fixed contact *f*, is secured to the base of the chamber containing the centrifugal separator. This turbulator, it may be recalled, consists of blocks of insulating material assembled to form an enclosure which is vented transversely by a series of slots, these slots being proportioned to suit the short-circuit to be broken. The arc is directed towards the vents magnetically and is thus kept in the most favourable position for extinction. The moving contact member *g* consists of a metal tube, the outer diameter of which is slightly smaller than that of the turbulator throat. This tube is fitted with a piston, so that when it moves downwards, as the circuit is interrupted, the oil inside it is forced into the turbulator. The effect of the piston is twofold; in the first place, it provides a pressure-balance so that the pressure generated inside the turbulator has little influence on the acceleration of the contact and a controlled uniform opening speed is therefore maintained at all currents; in the second place, oil passing into the turbulator prevents the formation of a void on the withdrawal of the moving contact and the efficiency of arc extinction is thereby increased.

The upper end of the moving-contact member is fitted with a removable tip. This tip has a copper-tungsten arcing surface which, it is claimed, is particularly suitable for dealing with a number of short-circuit operations without undue burning. It engages with an upper fixed contact *f*, which consists of a number of stationary contact fingers. Two of these have extended copper-tungsten tips and form the arcing contacts. The moving contact member *g* slides inside a sleeve, which constitutes the lower fixed contact *h*, and its lower end is attached to a Bakelised paper tube which, together with a metal rack, *i*, that meshes with a pinion on the main operating shaft *k*, forms the operating plunger *l*. The upper and lower fixed contacts, *f* and *h*, are attached to terminals *m* and *n*, at the ends of the porcelain surrounding the circuit-breaking chamber, to which the incoming and outgoing connections are made. The moving contact *g* travels vertically upwards or downwards when the main operating shaft is rotated by a pneumatic mechanism. Circuit breakers of this type are intended for power stations and major transmission substations, their interrupting capacity being 1,500 MVA.

The Enfield Cycle Company Limited, Redditch, recently entered the Diesel-engine market, and the exhibits on their stand at Castle Bromwich included single-cylinder and two-cylinder air-cooled units of this type. An example of the two-cylinder engine is illustrated in Fig. 27, on page 487, from which it will be seen that it is of the horizontal type, the cylinders being fitted to opposite sides of the crankcase. The bore and stroke are 85 mm. and 100 mm., respectively, and at the maximum governed speed of 1,800 r.p.m., 13·4 brake horse-power is developed at the 12-hour rating and 14·8 brake horse-power at the one-hour rating, the fuel consumption being 0·39 pint per brake horse-power per hour at 1,500 r.p.m. The cylinder barrels and cylinder heads consist of heavily-finned low-expansion aluminium-alloy castings. The cylinders are fitted with cast-in liners, while the cylinder heads are provided with cast-in valve seats, combustion chambers and ports. Cooling air is supplied by a fan bolted to the flywheel, with an output of 900 cub. ft. per minute, the air being led through volutes to the cylinders and cylinder heads. The crankshaft is of heat-treated alloy steel and is supported in an aluminium crankcase by bearings of the renewable copper-lead type. Aluminium-silicon alloy pistons are fitted, and each piston is provided with three compression rings and two oil control rings. The connecting rods, which are made of 3½ per cent. nickel steel, are fitted with copper-lead big-end bearings and the pistons are secured by floating gudgeon pins. The fuel-injection equipment consists of a standard C.A.V. pump and single-hole nozzles, the quantity of fuel injected being controlled by a centrifugal governor fitted to the end of the crankshaft; the governor can be set to give any predetermined speed between the limits of 1,200 and 1,800 r.p.m.

The exhibits on the stand of the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, included a model of the 2-MW gas turbine, which is to be erected in the firm's power-station. This is of the axial-flow type similar to the Metrovick jet engine for aircraft, and the turbine installed last year in a gunboat.

Among the other exhibits mention may be made of the "Turbovisory" gear, which has been developed for accurately indicating and recording the differential axial expansion between the stator and rotor of a steam turbine during running up and shutting down. This is combined with other

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

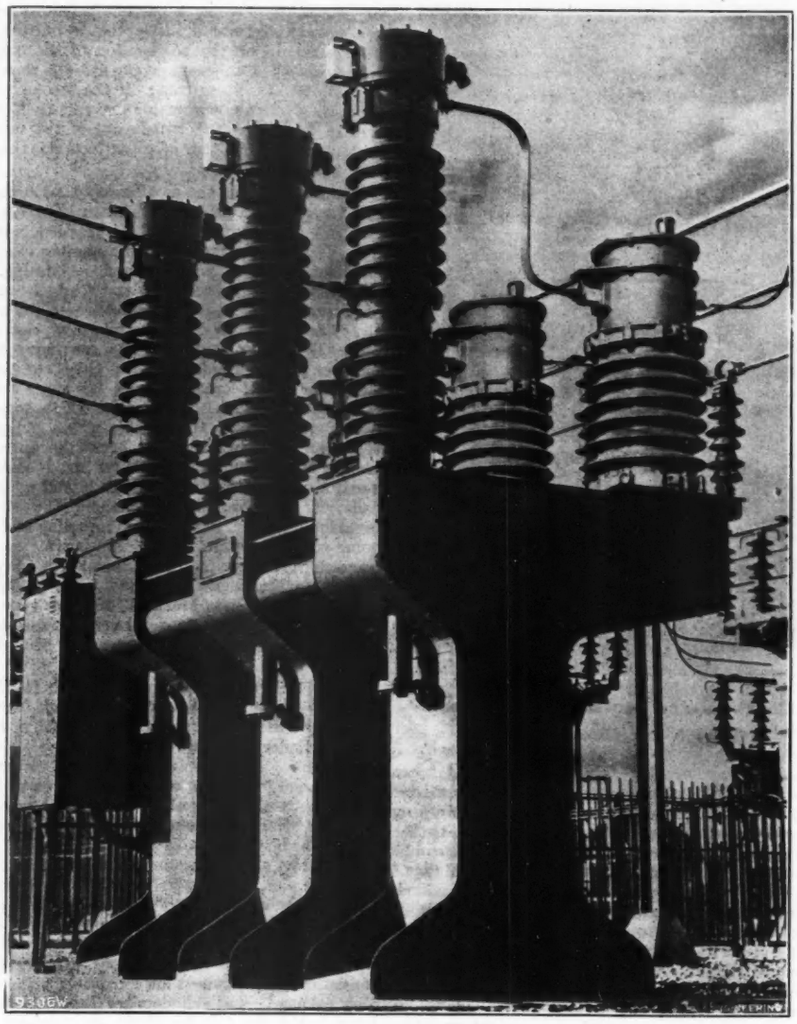
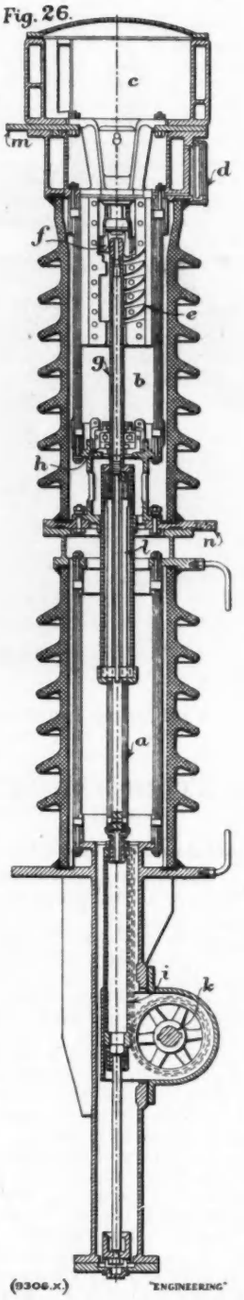


FIG. 25.

FIGS. 25 AND 26. 66-KV. SMALL OIL VOLUME CIRCUIT BREAKER; MESSRS. A. REYROLLE AND COMPANY, LIMITED.

Fig. 26.



equipment for measuring any eccentricity of the rotor shaft in the high-pressure or intermediate-pressure cylinders, which may arise from unbalanced heating. The axial-expansion recording equipment consists essentially of two similar U-shaped laminated cores with magnetising windings on each limb, which are fixed to brackets on the turbine bearing pedestal on each side of a Bibby coupling on the shaft. They are located so that any relative axial movement between the shaft and the stator will give the same variation in the length of the air gaps between the faces of the coupling and the pole faces of the detectors. The magnetic circuit of each detector is completed through the two air gaps and the coupling, so that any changes in the air gaps due to relative movement between the shaft and stator will vary the impedance of the detector windings. The air gaps of the two detectors are adjusted so that they are the same when the turbine is cold and at uniform temperature. The same current, therefore, passes through each, when equal alternating voltages at a frequency of 50 cycles per second are applied to them, and under these conditions a zero reading is shown on the difference-current instrument connected to them. If, however, relative axial movement takes place between the coupling and the detectors, the air gaps of the latter become unequal and a difference-current, which will be shown on the instrument, is generated. This current bears a linear relationship to the relative movement between the shaft and the stator and the instrument can be calibrated accordingly. The range of relative displacement covered by the instrument is $\pm$ 0·2 in., indications on one side of the centre-zero representing an expansion of the rotor relative to the cylinder and on the other an expansion of the cylinder relative to the rotor.

Any eccentricity of the shaft is measured by two detectors, which are placed outside the front-end bearing pedestal and about 12 in. from the centre of this bearing, respectively. Again, each detector consists of a laminated iron core with a coil on each limb. These detectors are fitted round the shaft so that an air gap of $\frac{1}{16}$ in. is left. The coils of the detector are connected to an alternating-current source with a frequency of 500 cycles per second. Each detector, therefore, forms a choke, the magnetic circuit of which is the core, the turbine shaft and the two air gaps in series. If the shaft is eccentric, when it rotates the length of these air gaps will vary in amplitude according to that eccentricity and in frequency according to the speed. The current in the detector coil is therefore modulated, the depth of the modulation being a measure of the amount of eccentricity. Two detectors are used to obtain a differential effect and to balance certain electrical circuits.

The recording equipment designed for use with this apparatus is, in principle, of the electronic type. It comprises a power unit which provides high-tension stabilised direct-current and alternating current for heating the valves; an oscillator with an output of 2·3 watts at 110 volts R.M.S., which provides current at 500 cycles per second and a control unit containing devices for converting the modulated detector-coil current into steady direct current. There are also circuits for maintaining the sensitivity of the electrical circuits by providing calibrating signals and a test instrument for verifying the performance of the equipment. Both recording equipments are housed in a cubicle, illustrated in Fig. 28, opposite, at a convenient distance from the turbine. Each unit is mounted on runners so that it can be removed easily for inspection, while the cubicle itself is mounted on resilient supports, so that operation is not affected by vibration. The two recorders give continuous records

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

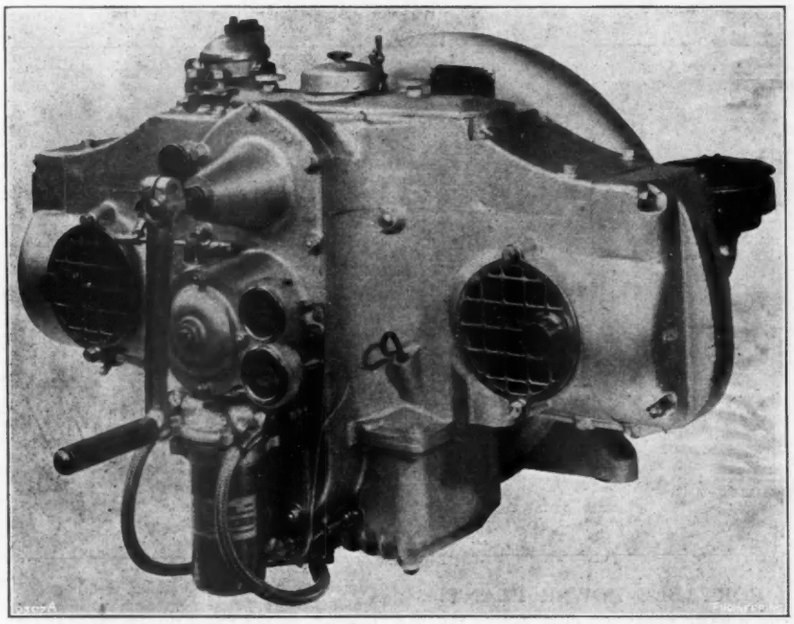


FIG. 27. AIR-COOLED DIESEL ENGINE; ENFIELD CYCLE COMPANY, LIMITED.

of the differential axial expansion and shaft eccentricity on 3½ in. charts, which are driven at a speed of 3 in. per hour by a synchronous motor. The complete equipment is run continuously and has a power consumption of about 250 watts.

The exhibits on the stand of Messrs. Brookes (Oldbury) Limited, Oldbury, Birmingham, included the guillotine-shearing machine illustrated in Fig. 29, on page 492. The machine is designed to cut 8 ft. of ½ in. thick mild-steel plate and is particularly suitable for all forms of sheet shearing where close accuracy is required. It is fitted with a new type of pneumatic hold-down, which is timed to operate in advance of the cutting action. The air cylinders, however, are of the single-acting type, the hold-down being returned to its top position by the action of cams. The cams also lower the hold-down, so that it is brought close to the plate before air is admitted to the cylinders. This arrangement, it is claimed, reduces the impact of the hold-down on the plate to a minimum and prevents the setting of the sheet from being disturbed. In addition to exerting a steady pressure on the plate during the cutting or shearing operation, the pneumatic-type of hold-down has the added advantage of automatically adjusting itself to variations in the thickness of the plate. The machine is fitted with a screw-operated back gauge and provision is made for adjusting the screws either together or separately so that, when required, the back gauge can be set at an angle. The front gauge equipment consists of two extension arms arranged so that they can be adjusted to any position along the front of the machine. Each arm is provided with a sliding stop which works in conjunction with a built-in stainless-steel scale. An 8-ft. squaring arm is provided and this is fitted with two adjustable stops of the swing-over type which also work in conjunction with a built-in scale. The machine is operated through a pedal-controlled roller-key clutch, which stops the machine automatically at the top of the stroke and gives only one stroke regardless of whether the pedal is released.

Messrs. Aveling-Barford, Limited, Grantham, were exhibiting in the outdoor section of the Fair, the main feature of their stand being a display of Diesel-engined road rollers. One of the rollers is illustrated in Fig. 30, on page 492. This is known as the GD10 machine and, as the type letters and figures imply, the weight of the machine when empty is 10 tons. The roller is driven by a vertical three-cylinder four-stroke Diesel engine, which is governed at 1,500 r.p.m. and develops 33 brake horse-power. The drive from the engine is transmitted to a four-speed gearbox through a double reversing fabric-lined clutch, an arrangement which provides four speeds in both the forward and reverse directions of travel. The gearbox is of fabricated-steel construction and all shafts within the gearbox run in either ball or roller bearings. The differential gear is housed within the gearbox and is arranged so that it can be locked from the driver's seat. The final drive to the rear rollers is through double internal gears, each rear roller being driven independently by a gear ring bolted directly to it and completely enclosed. The frame of the roller consists of two heavy rolled-steel channel-section members fitted with suitably-braced side plates. The steering fork, which is of cast steel, spans the front roller in the fore and aft direction and is pivoted to the underslung forecarriage. Two independent braking systems are provided, one foot and the other hand operated. Both are of the contracting-band type and operate on the drums formed by the final drive internal-gear rings, which are fitted to the rear rollers. The rollers are of the water-ballast type. They are fabricated from steel plate and are fitted with renewable hub bushes; with water ballast in the rollers, the machine has a total weight of approximately 11 tons 10 cwt. An interesting feature is the incorporation of a device whereby the relative pressures on the front and rear rollers can be varied. This consists of a movable weight situated within the main chassis members which, in its forward position, gives equal pressure on both front and rear rollers but when in the rearmost position increases the pressure on the rear rollers. The weight is carried by small wheels and it is moved to the required position by a simple rope-and-pulley mechanism, which is operated by the starting handle.

Among the exhibits displayed by the English Electric Company, Limited, Queens House, Kingsway, London, W.C.2, mention may be made of a full-scale sectional model of a 500-MVA 11-kV air-blast circuit breaker. This is of the axial flow type in which the directions of the compressed air and arc are the same. As can be seen from Fig. 31, on page 492, the fixed and moving contacts and the resistor and main air way channel are all contained in an insulating pillar, which is mounted on a base alongside the compressed-air receiver. Insulating

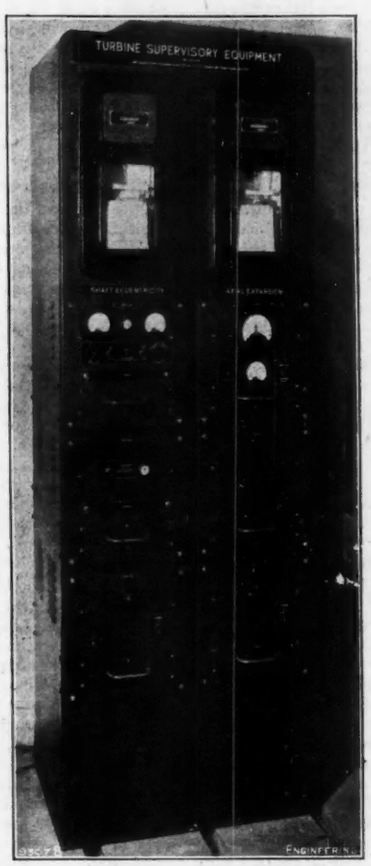


FIG. 28. TURBINE SUPERVISORY EQUIPMENT; METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED.

supports are bolted to a horizontal plate, which is welded to the top of this receiver, and carry one set of terminals, which are connected to the moving contact through isolating links and a flexible lead. The other set of main terminals is connected directly to the fixed contact. This fixed contact has a conical vertical hole through its centre and a seating of similar shape on its underside. The head of the moving contact is forced against this seating by a spring, thus ensuring line contact between the two surfaces. A piston is attached to the lower end of the stem and controls a port through which compressed air is admitted to the isolator-operating mechanism. An arcing contact, which projects downwards into the interrupter chamber, is arranged axially above the fixed contact. This arcing contact is connected to a resistor which, in turn, is connected to the moving contact. The resistor is wound non-inductively round the outside of a cylindrical cooler and exhaust unit and is mounted at the top of the pillars.

When the breaker is tripped, a blast of air forces the piston of the moving contact downwards against the action of the spring, so that an arc is drawn between the fixed and moving contacts and the onised products are blown into the interrupter chamber. Re-striking across the main gap is prevented by the upward sweep of high pressure un-ionised air, but takes place across the longer gap between the arcing contacts in the ionised interrupter chamber. The resistor is thus placed in series with the arc thereby reducing the size of the latter and assisting in its rapid extinction.

Compressed air at a pressure of 250 lb. per square inch is stored in a receiver, a pipe from which is connected to a small valve chamber containing ports leading to the trip and closing valves, both of

which are electromagnetically operated. When the trip valve is opened, compressed air is admitted to one side of a spring-loaded piston, which is attached to one end of the horizontal stem of the blast valve. The diameter of this valve is smaller than that of the piston and it is normally held against a seating in the receiver by air pressure and the action of a spring. After the trip valve has operated, the total pressure on the valve chamber side of the piston overcomes the spring and the receiver pressure. The blast valve therefore opens and compressed air is admitted to the main contacts when the arc is formed and then extinguished, as already described.

When the breaker is open, the length of the main gap is insufficient to prevent flash-over occurring under atmospheric conditions and the necessary clearance is therefore provided by isolating links. These links are operated by the small piston visible in Fig. 31 on the left-hand side of the pillar assembly. A blast of air is admitted through a non-return valve to one side of the piston after tripping has occurred, thus ensuring that the isolating links do not break any current. A gate then engages a pin on the moving contact and holds the latter in the open position. The air supply from the receiver is also automatically cut off by an auxiliary switch. When the "close" contact is actuated, the compressed air is admitted to the back of the isolator piston so that the links begin to close. The moving contact is also released and the spring closes it on to the fixed contact. The isolators then close in turn, thus ensuring that the circuit is made on the isolator and not on the main contacts.

A range of hydraulic centrifugal pumps was exhibited by Messrs. Girdlestone Pumps, Limited, 23, Davies-street, London, W.1. There are 13 pumps in the range, the diameter of the suction and delivery corrections being from ¾ in. to 5 in. The 1½-in. pump is illustrated in Fig. 32, on page 492. It will be seen that the electric motor and pump are built into a common housing and pedestal, thus rendering a flexible coupling unnecessary. The three-phase motors are totally enclosed, but on two of the pumps single-phase motors can be used and these are only "drip proof." The larger sizes of motors are fan-cooled. The double-shrouded impellers are of bronze or cast-iron. The spindles run on ball bearings and the glands are readily accessible. The speed of the pumps is between 960 r.p.m. and 2,900 r.p.m., according to size, and they can be used for suction lifts up to 25 ft.

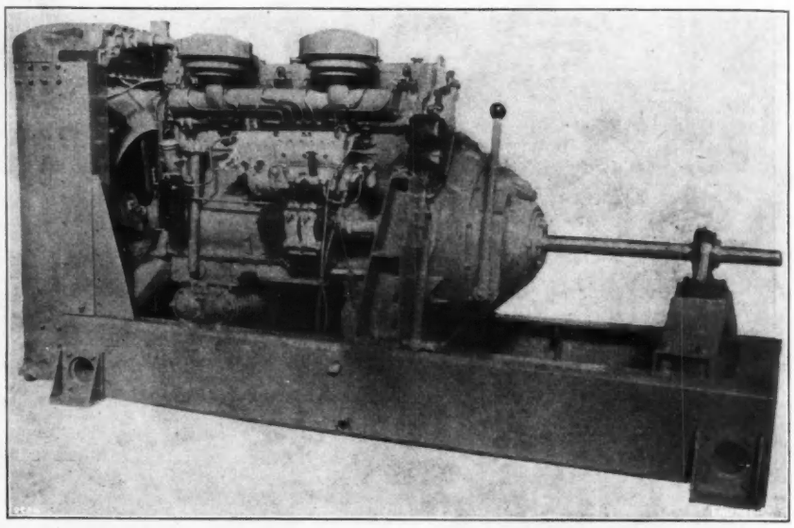
A rotary converter for providing fluorescent lighting on road passenger vehicles was shown on the stand of Messrs. C.A.V., Limited, Acton, London, W.3. This converter, which is illustrated in Fig. 33, on page 492, is supplied from a 24-volt battery and has a three-phase output of about 400 watts at 100 volts and 400 cycles per second. It runs at 8,000 r.p.m., weighs 13 lb., and is 9 in. in length. It has a single armature and a common six-pole field system. Owing to the high-speed hum of the set, it is necessary to make it sound proof, and for this purpose it is suspended on rubber in a container, which nevertheless provides ample ventilation. The container is 15 in. in length and 11 in. in diameter, and the complete unit weighs 30 lb. The converter is cooled by a fan which draws in air through an entry at the motor end, and expels it over the slip rings. Plug and socket connections are mounted on the ends of the container. The switchboard provided for use with the converter contains a solenoid-operated switch for connecting the motor to the battery, and a thermal-delay switch, which is arranged to allow the machine to run up to its normal frequency before connecting the alternating-current supply to the tubes.

(To be continued.)

STEEL AND IRON PRODUCTION IN THE UNITED KINGDOM.—Steel production in April was at the annual rate of 15,283,000 tons, which figure constitutes a new high record. This compares with a rate of 15,117,000 tons in March, the previous record, and only 12,294,000 tons in April, 1947, when production was affected by the fuel crisis. The pig iron output also improved, reaching an annual rate of 9,433,000 tons in April, 1948, compared with 9,303,000 tons in March, 1948, and 7,238,000 tons in April, 1947.

PORTABLE POWER PLANT.

MESSRS. HENRY MEADOWS, LIMITED, WOLVERHAMPTON.



PORTABLE POWER PLANT.

THE portable power unit illustrated on this page has been developed by Messrs. Henry Meadows Limited, Fallings Park, Wolverhampton, to meet the need for a compact, easily transportable source of power for the direct driving of plant and machinery. The unit, which has been designated the Power Mule, is fitted with a six-cylinder compression-ignition oil engine developing a maximum continuous output of 94 brake horse-power at 1,600 r.p.m. It has a bore and stroke of 5½ in., which gives a capacity of 633 cubic inches, or 10·35 litres.

The engine is of straightforward construction, forming a single unit with the clutch. The crankcase and cylinders are a monobloc casting and the cylinders are fitted with renewable dry liners. The cylinder heads form two separate but interchangeable castings, each head covering three cylinders, and they are fitted with overhead valves operated in the usual manner by push rods and rocking levers. The valves are made from heat-resisting steel and work on hardened renewable valve-seat inserts. The crank-shaft is a steel forging and is carried in seven steel-backed indium-flashed lead-bronze bearings. The pistons are of aluminium alloy and each is fitted with three compression rings and two scraper rings, one above and one below the gudgeon pin. H-section connecting rods are employed and have been designed so that they can be withdrawn through the cylinder bores. The big-end bearings are of the steel-backed indium-flashed lead-bronze type.

The camshaft is a steel forging with integral cams, and runs in seven bearings. It is driven through helical gears from the flywheel end of the engine and operates the short push rods through cast-iron tappets. All bearings within the engine are pressure lubricated, the oil being supplied by a gear-type pump driven through helical gears. The oil is drawn from the sump through a floating filter and, after passing through an oil cooler, flows through two large star-shaped fabric filters situated at the front of the engine. The oil then passes to a main gallery which distributes it to the main bearings, timing gears, camshaft and rocker gear. The crankshaft is drilled for big-end lubrication and the gudgeon-pin bearings are, in turn, lubricated from the big-ends through oilways drilled in the flanges of the connecting rods. An interesting feature of the lubricating system is the provision of an auxiliary sump under the camshaft for the lubrication of the cam lobes and push rods. The engine is cooled by a large-capacity radiator which is used in conjunction with a pusher-type fan fitted directly to the front of the crankshaft. Cooling is assisted by a water-circulating pump driven by a V-belt from the front end of the crankshaft.

The injection equipment consists of a C.A.V. fuel pump which is used in conjunction with four-hole spray-type injectors, also of C.A.V. manufacture. Idling and maximum speeds are controlled by a centrifugal governor integral with the fuel pump, while the injection timing is controlled automatically by a Meadows governor fitted to the fuel-pump drive. The fuel is fed to the injection pump by a C.A.V. plunger type pump, in which is incorporated a hand priming device. Before entering the injection pump, however, the fuel passes through two filters, the first of which is fitted with a metal element while the second is fitted with a star-shaped fabric element.

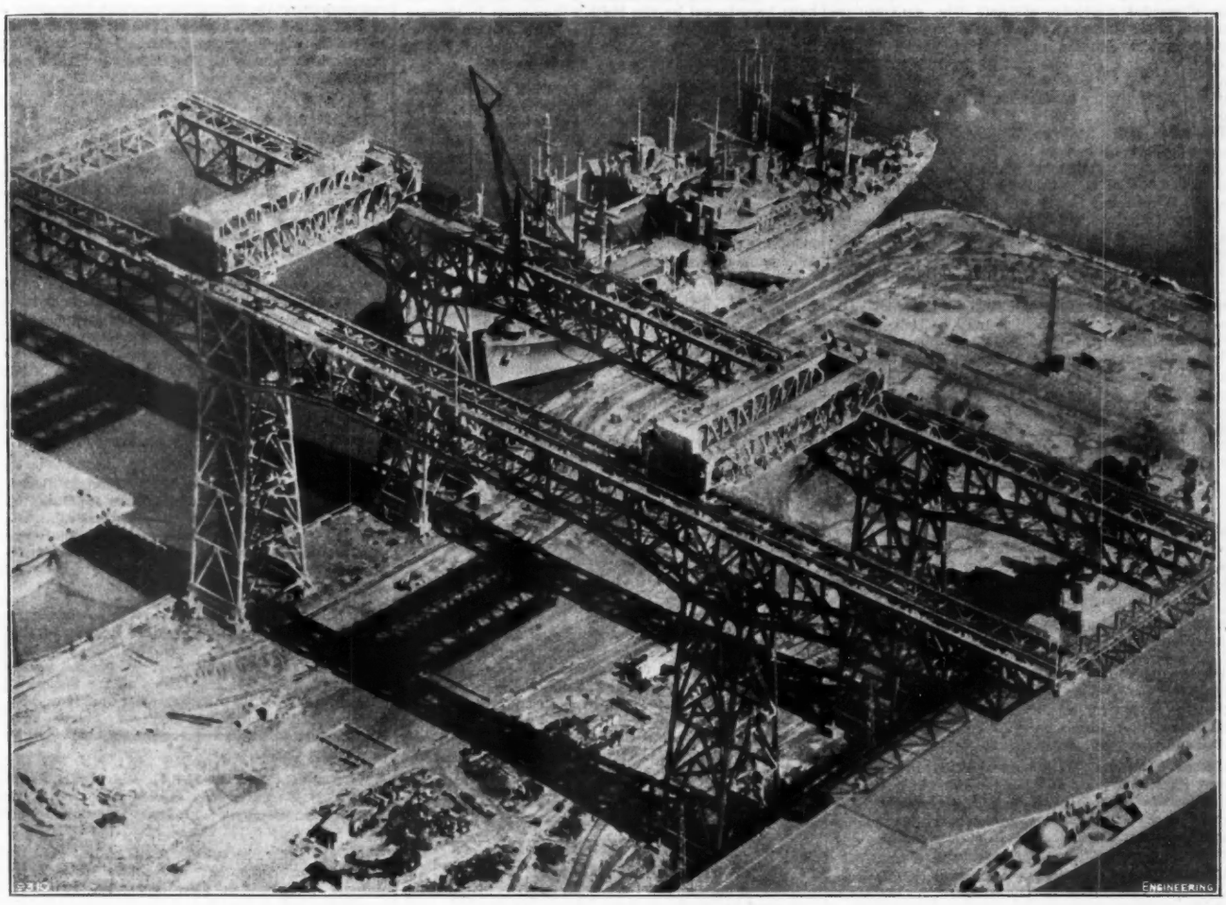
The engine is fitted with a hand-operated over-centre clutch and, as will be seen from the illustration, this is arranged to drive an extension shaft supported by an outrigger bearing. The extension shaft is designed to accommodate either a V-belt or a flat-faced pulley up to a maximum diameter of 23 in. and a maximum width of 16 in.; alternatively, direct drive can be arranged from the outer end of the extension shaft. The engine assembly, radiator and outrigger bearing are fitted to a heavy bedplate fabricated from channel-section steel 12 in. deep and provided with four holding-down feet. Auxiliary equipment provided with the unit includes a 24-volt axial-type starter motor, together with ancillary battery and dynamo, a tachometer, an oil pressure gauge and an ammeter; the tachometer also incorporates a running-hour meter.

The weight of the complete unit when dry is 3,850 lb., and the overall length, breadth and height are 8 ft. 6in., 3 ft. 4 in., and 4 ft. 10 in., respectively. The dimension for the overall width, however, does not cover the holding-down feet; when these are included, the overall width is increased to 3 ft. 10 in. The Power Mule can be supplied either as shown in the illustration or fitted with a canopy, and side and end covers.

BRITISH TRANSPORT STATISTICS.—The first issue of *Transport Statistics* has been published by the British Transport Commission. It contains statistics relating to traffic receipts, man-power, rolling stock, vessels, traffic, mileages, locomotive coal consumption, etc., of the Railway Executive, London Transport Executive, and Inland Waterways Executive. The first issue refers to the four-weekly period which ended on January 25, 1948; but in a foreword, the chairman of the Commission, Sir Cyril Hurcomb, expresses the hope that it will soon be possible to publish the figures within the month following the period to which they refer. Copies of *Transport Statistics* may be obtained from British Railways, 71, Regent-street, London, W.1, at the price of 1*s.* 2*d.* per copy, including postage; the annual subscription, for thirteen copies, is 12*s.* 6*d.*

SUMMER SCHOOL IN ELECTRON MICROSCOPY.—A summer school in electron microscopy will be held from August 18 to 24 in the Cavendish Laboratory, Cambridge. It will provide a grounding in the theory and applications of the electron microscope, and is intended for those who have some familiarity with the instrument. The lectures given will deal with the fundamental theory and operating principles of the instrument. The various techniques of specimen preparation will be demonstrated and practised in small groups by the class. A detailed syllabus and form of application for admission may be obtained from Mr. G. F. Hickson, M.A., secretary of the Board of Extra-Mural Studies, University of Cambridge, Stuart House, Cambridge, to whom the complete application form should be returned not later than June 12.

450-TON OVERHEAD TRAVELLING CRANE.



450-TON OVERHEAD TRAVELLING CRANE.

WHAT is claimed, probably correctly, to be the largest crane in the world was put into operation last autumn at the United States Navy Yard at Hunter's Point, San Francisco. It was designed by the Navy Bureau of Yards and Docks, the runway structure being built by the American Bridge Company, and the travelling gantries and trolleys by the Alliance Machine Company. The general arrangement of the crane is clearly shown by the photograph reproduced on this page. It consists of two runways, each 730 ft. long, and each carried by two towers placed at 320-ft. centres, the runways being 142 ft. apart. The towers are 50 ft. by 35 ft. at the base and the rails of the runway structure are 182 ft. above the deck of the pier on which the crane stands. This pier is 405 ft. wide, so that the centilever arms forming the ends of the runways project 162·5 ft. beyond the pierhead line at each side. One of the berths alongside the pier is 1,700 ft. long, and the other 1,000 ft. Each of the two travelling gantries is capable of lifting a weight of 245 long tons, and the two coupled together in tandem can handle 450 tons. The crane has been built to facilitate repair work on major naval vessels; it can lift an entire battleship turret as a unit. Vessels moored on opposite sides of the pier can be serviced simultaneously.

The pier on which the crane stands was constructed to accommodate it. The site was covered by a sandy clay lying some 100 ft. below low-water level, with a firm rock foundation about 100 ft. deeper. For the construction of the pier, a trench 80 ft. wide was excavated around the site down to the firm sandy clay, all mud and foreign matter being removed. The trench was then refilled with sand to a level of about 45 ft. below low water, and a sheet-pile cofferdam, made up of circular units, was driven around the perimeter of the pier. The area inside this structure was then filled, the cofferdam retaining the fill and leaving deep-water berths on each side of the pier. The whole weight of the crane and the load it is carrying comes on the four towers. These rest on steel H piles about 92 ft. long. In all, 540 piles were driven, in groups, under the tower footings. The piles do not reach the firm sandy clay underlying the site, which lies some 15 ft. to 25 ft. below their lower ends. This arrangement was deliberately adopted, as it was considered that piles, or deep caissons, extending to the firm bottom would have been unduly expensive and would have occupied too much time in installation. As a result of the arrangement adopted some settlement was expected, and provided for, and care was taken not to drive the piles into the firm material as this might have resulted in uneven settlement. The piles were designed to carry 75 tons each, but some in each group were tested with loads of 150 tons. It is expected that any settlement will be uniform, but to correct any uneven effect each tower leg is provided with a jacking bracket which can be supported on a 500-ton jack while levelling shims are inserted. A similar arrangement is provided to correct any differential displacement in a horizontal direction.

The trolleys of the travelling gantries each have a main hook able to lift 245 long tons at a speed of 10 ft. per minute, and an auxiliary hook lifting 50 tons at 30 ft. per minute. The combined lifting capacity of the two main hooks is 450 tons, the difference between this figure and the sum of the single lifts being due to the fact that the equaliser beam and hook weigh 40 tons. The main hooks can lower at 25 ft. per minute and, when empty, can lift at 30 ft. per minute; the auxiliary hook can lower at 75 ft. per minute and hoist at 90 ft. per minute, when empty. A 245-ton load can be carried out 130·5 ft. over the water beyond the pier side, or 148 ft. beyond the outer face of the towers. The range of operation of the main hook is from 25 ft. below to 160 ft. above mean water level, the corresponding figures for the auxiliary hook being 35 ft. and 191 ft. A 450-ton load, carried by the gantries in tandem, can be moved outward to a point at which its centre line is 78·5 ft. beyond the pier side. Each gantry and trolley with a full hook load weighs about 770 tons, and the two together with a 450-ton load about 1,600 tons. The gantry wheels which travel on the runway each carry a load of 78 tons. In order to reduce the constructional weight as much as possible, considerable use has been made of aluminium alloy in the framework of the trolleys. Some of the members are entirely of aluminium, while others are of composite construction, these latter being assembled with cadmium-plated bolts. Joints between aluminium and steel have a layer of insulating material. These arrangements have reduced the weight of each trolley by about 50 tons.

The crane is controlled from operators' cabins situated above and at the ends of the gantries; they can be seen in the illustration. The positions occupied by the operators gives them a good view of the load being handled, but this facility is not entirely relied on in the working of the crane, the operators being connected by radio-telephone with an observer on the ground. For the greater part of the time, the two gantry cranes will be working independently and the operator of each controls all lifting and traversing motions. When the cranes are working in tandem, as a single unit, one operator controls the travel of the gantries along the runway, but trolley movement and lifting are still controlled independently. To assist this dual control of the main hoisting operation the equaliser beam is fitted with indicator lights at its ends. They are controlled by mercury switches and supplied from a storage battery. When the beam is less than 5 deg. out of level, green lights are in operation, but if that inclination is exceeded, the red light on the higher end lights up.

Power for operating the crane is supplied from a transformer substation located in the upper part of one of the towers, the incoming 11,300-volt three-phase supply being stepped down 480 volts. A connection at this lower voltage is carried to a second substation in the opposite tower from which 120-volt circuits for lighting and small-power uses are supplied. The main power-supply arrangements of the crane are probably novel; alternating-current motors are used for all traversing motions and direct-current is employed for the operation of the hoists. Each gantry carries a converting set consisting of a 400-h.p. squirrel-cage motor driving two 125-kW generators and exciters. Each set supplies the hoist on its own gantry and an obvious advantage of the arrangement is that, if one motor-generator set breaks down, only half the capacity

of the crane will be affected. It is claimed that this dual operation with direct- and alternating-current drives has saved a capital expenditure of 40,000 dols. when compared with full direct-current operation from a ground converter station. The gantries are traversed along the runway by four 50-h.p. alternating-current motors situated one at each corner of the runway structure, opposite motors on different tracks being connected by a cross shaft. The motors for the traverse of the gantry trolleys are of the same size and type.

The main hoist has two brakes of the spring-set power-release type and two of the power-set spring-release type. All brakes are released when the master switch is notched to a running position, and re-set when it is returned to the off position. Stall relays in the control lines automatically limit the possible overload. Special arrangements have been incorporated to cover the eventuality of the crane being rigged to a load still bolted to a ship and left in that condition while other work preparatory to lifting is completed. If during this condition the tide falls, undue stress may come on the lifting tackle and it may be broken. To prevent this, the control of the power-release brakes includes a time relay which frees them about 30 seconds after the master switch is moved to the off position. The spring-set brakes are capable of holding the maximum load which the stall relays will permit the crane to lift, but if, owing to a falling tide, the load reaches 170 per cent. of the rated load, the brake wheels will slip and pay-out cable.

CONTRACTS.

MESSRS. THE HUNSLET ENGINE COMPANY, LIMITED, Leeds, 10, have received from the National Coal Board and from heavy industries, orders for fourteen of their 48½-ton "Austerity" saddle-tank locomotives, of which 377 were built during the war years.

MESSRS. ASSOCIATED BRITISH OIL ENGINES LIMITED, Duke's-court, 32, Duke-street, St. James's, London, S.W.1, have received from the Intercontinental Engineering Company, of Brussels, an order for six Mirrlees "TLRA 6" six-cylinder marine Diesel engines rated at 270 b.h.p. at 500 r.p.m., for installation as propulsion units in existing Rhine barges owned by Messrs. de Proost and Company, Antwerp.

MESSRS. PHILIPS ELECTRICAL LIMITED, Century House, Shaftesbury-avenue, London, W.C.2, have sent out to Buenos Aires, Argentina, a large consignment of hospital X-ray equipment, comprising six heavy-duty diagnostic units, six motor-driven tilting couches, and ultra short-wave electro-medical treatment equipment.

MESSRS. JESSE TILDESLEY, LIMITED, Darlaston, Staffordshire, have received the contract for the steel-work for reconstructing the superstructure of the bridge which carries the British Railways (London Midland Region) Churnet-Valley Line over the River Churnet, between Kingsley and Froghall and Oakamoor stations, Staffordshire. The existing wrought iron superstructure and wood flooring of the bridge are to be dismantled and replaced by 65 tons of steel main- and cross-girders and a new concrete floor; the original piers of the bridge will remain.

The British Electricity Authority, Great Portland-street, London, W.1, announce that during the period since April 1, contracts have been placed for generating-station, switching and transforming-station and transmission equipment amounting, in the aggregate, to 1,501,782*l*. The principal contracts include piping equipment for Barking Generating Station with MESSRS. AITON AND COMPANY, LIMITED; cast-iron segments for the circulating-water system at Deptford East Station, with MESSRS. STANTON IRONWORKS COMPANY, LIMITED; circulating water pumps and equipment at Barking Station, with MESSRS. DRYSDALE AND COMPANY, LIMITED; station transformers and unit and auxiliary transformers at Keadby Station with MESSRS. C. A. PARSONS AND COMPANY, LIMITED; concrete chimneys at Poole Station with MESSRS. TILEMAN AND COMPANY, LIMITED; circulating water pumps, transfer pumps and equipment at Skelton Grange Station with MESSRS. W. H. ALLEN, SONS AND COMPANY, LIMITED; and 132 kV and 66 kV switchgear at Colchester with MESSRS. A. REYROLLE AND COMPANY, LIMITED.

"BRITISH JEFFREY-DIAMOND, LIMITED, 1897-1947."—The publicity now given to coal-cutting by machinery tends to give the impression that this is a recent development, but the British Jeffrey-Diamond Company, of Wakefield, have now been engaged in this branch of mining engineering for more than half a century; and, as their jubilee brochure shows, William Garforth—founder of the firm, and pioneer of the use of stone dust to reduce explosion risk in mines, for which he was knighted in 1911—had been experimenting with mechanical coal-cutters ten years before the company was formed, and he was by no means the first. The text of the brochure is general in character rather than particular, but it is well supplemented by numerous illustrations.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Bell and Call Systems.—The Codes of Practice Committee for Civil Engineering, Public Works and Building, formed under the ægis of the Ministry of Works, have now issued as a draft for comment Code No. 327.401, covering bell and call systems. It has been prepared by a committee convened by the Institution of Electrical Engineers on behalf of the Codes of Practice Committee. The draft deals with the installation of electrical bell and indication call systems, including time bells, for use in private dwellings, hotels, schools and factories. Guidance on burglar alarms and watchmen's supervisory services is also given. Bells for fire alarms are not included, since they are being dealt with in Code No. 327.404. The recommendations contained in the Code apply to installations for use in temperate climates only. The draft stresses the importance of close co-operation between the architect, the contractor and the client, so that the initial and ultimate requirements of the building can be established at an early stage, and the plans prepared for the accommodation of the central equipment and the provision of ducts, chases and conduits for the wiring. Comments on the contents of the Code received up till June 16 will be examined by the Code and Drafting Committee. The final draft will be submitted by the Engineering Services Sectional Committee for the approval of the Codes of Practice Committee. [Price 2*s*., postage included.]

Gas Lighting Units and Fittings.—A recommended standard of lighting for single-family dwellings is laid down in Functional Code C.P. 7, Chapter VII (F.), and the Institution have now published a specification, B.S. No. 1381, which will assist manufacturers and users in implementing the requirements of the Code. The specification covers gas-lighting units and fittings for single-family dwellings and stipulates minimum standards for the efficiency of burners and units, the thermal endurance of glass and silica ware, and the maximum permissible brightness. It also includes tests for the soundness of components of lighting units conveying or controlling gas. [Price 2*s*. 6*d*., postage included.]

BOOKS RECEIVED.

The College of Aeronautics, Cranfield. Report No. 14. *Notes on the Limits to the Local Mach Number on an Aerofoil in Subsonic Flow.* By A. D. YOUNG. The Librarian, The College of Aeronautics, Cranfield, Buckinghamshire. [Strictly limited issue; copies free to approved firms, Institutions and official bodies.]

A First Year Engineering Drawing. Covering the First Year National Certificate Course in Mechanical Engineering. By A. C. PARKINSON. Fourth edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 6*s*. 6*d*.]

Rubber to Metal Bonding. By DR. S. BUCHAN. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 21*s*. net.]

Moulding of Plastics. A Practical Work for Plastic Moulders. By FRANK H. LAMBERT. George Newnes Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 21*s*. net.]

The Practical Motorist's Encyclopædia. Principles, Upkeep and Repair. By F. J. CAMM. Seventh edition. George Newnes Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 10*s*. 6*d*. net.]

Walschaerts' Valve Gear. By HENRY GREENLY. Revised by ERNEST A. STEEL. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 3*s*. net.]

Model Railway Signals: Their Construction, Installation and Operation. By ERNEST F. CARTER. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 3*s*. net.]

The Oakwood Library of Railway History. No. 3. *The Hull and Barnsley Railway.* By DR. G. D. PARKES. Second edition. The Oakwood Press, "Tanglewood," South Godstone, Surrey. [Price 4*s*. net.]

The Water Engineer's Handbook and Directory, 1948. A Guide to the Water Undertakings of the British Isles and Eire; and Catchment Boards of England and Wales; etc. Water and Water Engineering Offices, 30 and 31, Furnival-street, Holborn, London, E.C.4. [Price 15*s*.]

The Workshop Yearbook and Production Engineering Manual. No. II. Editor: H. C. TOWN. Paul Elek Publishers, Limited, 38, Hatton-garden, London, E.C.1. [Price 35*s*. net.]

The Graduate in Industry. By DR. PERCY DUNSHEATH. Hutchinson's Scientific and Technical Publications, 47, Princes-gate, South Kensington, London, S.W.7. [Price 10*s*. 6*d*. net.]

PERSONAL.

SIR CHARLES REID has resigned from the National Coal Board following a disagreement with the Board concerning certain arrangements which they are making to review their organisation. The Minister of Fuel and Power has appointed SIR GEOFFREY VICKERS, V.C., at present legal adviser to the Board, to fill the vacancy thus caused.

MR. D. R. LAMB, editor of our contemporary, *Modern Transport*, has been elected President of the Institute of Transport for the year commencing October 1, 1948. MR. W. J. EVANS is to be the first chairman of the new Berkshire, Buckinghamshire and Oxfordshire local section; MR. H. R. CAULFIELD-GILES has been made the first chairman of the reconstituted Sheffield and district section, and MR. H. HODSON chairman of the reconstituted Humberside section of the Institute of Transport.

At the annual general meeting of the Dry Dock Owners and Repairers Central Council, held in Edinburgh, on May 13, MR. R. H. STEPHENSON, O.B.E., a director of Messrs. Smith's Dock Company, Limited, North Shields, was re-elected chairman for a second year of office. MR. G. S. CROMAR, C.B.E., of Messrs. Barclay, Curle and Company, Limited, Glasgow, and MR. E. L. CHAMPNESS, of Messrs. Palmers Hebburn Company, Limited, Hebburn-on-Tyne, were elected senior vice-chairman and junior vice-chairman, respectively.

The North of Scotland Hydro-Electric Board, 16, Rothesay-terrace, Edinburgh, 3, have appointed MR. T. LAWRIE, formerly secretary, to be general manager; MR. W. D. D. FENTON, formerly commercial engineer, to be secretary and commercial engineer; and MR. H. W. SIMPSON, formerly assistant secretary, to be deputy secretary.

MR. JAMES TURNBULL, O.B.E., who has been principal surveyor of the British Corporation Register of Shipping and Aircraft, in London, since 1937, and who has been an assistant to the chief surveyor for the past seven years, will shortly be transferred to the Society's head office in Glasgow as assistant chief surveyor. He will be succeeded as principal surveyor, London area, by MR. R. IBISON, hitherto principal ship surveyor on the North-East Coast.

MR. ERIC G. YARROW, M.B.E., and MR. G. STURROCK BROWN, B.Sc., have been elected directors of Messrs. Yarrow and Company, Limited, Scotstoun, Glasgow, W.4.

MR. F. W. ABRAHAM, M.I.Loco.E., A.M.Inst.T., assistant superintendent of motive power, London Midland Region, has been appointed motive power superintendent of the Region, in succession to MR. H. RUDGARD, who became chief officer (motive power) Railway Executive, on January 1, 1948.

MR. I. C. FORSYTH, M.I.Loco.E., assistant works superintendent, Crewe Locomotive Works, London Midland Region, since 1946, has now been appointed works manager at these works.

MR. R. J. TURNER has been appointed general manager industrial sales of Messrs. C. C. Wakefield and Company, Limited, 46, Grosvenor-street, London, W.1. Other promotions include those of MR. J. A. V. WATSON, O.B.E., as general manager responsible for Castrol sales, and MR. A. A. BARR, as publicity manager.

THE INSTITUTION OF GAS ENGINEERS.—The eighty-fifth annual general meeting of the Institution of Gas Engineers will be held from June 8 to 11, in the Large Hall, Friends House, Euston Road, London, N.W.1. The meeting will open at 10 a.m. on the first day, when, after the official business, the President, Dr. Harold Hartley, will deliver his presidential address. Afterwards, a paper on "The Development of the Gas Industry in the Netherlands," by Professor G. A. Brender à Brandis, will be discussed. In the afternoon, from 3 to 5, two papers will be presented and discussed, namely, "Gas Production in Perspective," by Mr. T. C. Finlayson and Mr. F. S. Townend, and "Purification and By-Product Recovery: A Review," by Mr. C. Cooper and Mr. D. M. Henshaw. On Wednesday, June 9, from 10 a.m. until 12.15 p.m., two papers will be discussed, the first, "Functionalism as a Tool of Management," by Mr. C. H. Leach, and the second, "A Survey of Gas-Distribution Practice," by Mr H. J. Escreet. The afternoon will be devoted to industrial visits, including the Beckton Gas works. Two papers will again be presented and discussed on the morning of June 10, from 10 until noon. These will be: "A Survey of the Use of Gas for Domestic and Industrial Purposes, together with Factors Influencing Future Trends," by Mr. Stirling Everard, M.B.E., and "British Gas-Making Coals," by Dr. J. G. King, O.B.E. In the afternoon, visits will be paid to a number of works, and the whole of Friday, June 11, will be devoted to a trip to St. Albans, Harpenden and Whipsnade Park.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel—There has been a definite slight improvement in scrap deliveries to local works, and steel production continues at a high level. One of the largest furnaces had to be laid off for routine repairs, however, reducing the total production, but part of the loss was offset by speeding up melting operations in the remaining furnaces wherever possible. Pig-iron production has been maintained on the restricted basis imposed on blast-furnaces by limited coke supplies. Coal and other raw materials have been adequate for steelmaking requirements, the interruption to coal deliveries during the recent holiday at the pits having been successfully overcome. Shipbuilders are receiving heavy tonnages, but would prefer still larger quantities to build up stocks. Supplies for engineering firms are below requirements, the shortage of sizes under 3 in. square being acute in some cases. The Nethan Ironworks, between Motherwell and Bellshill, belonging to Messrs. Frederick Braby and Company, Limited, which were closed in the early years of the war, are to re-open for receiving and storing redundant materials for ultimate manipulation at the company's Glasgow rolling mills.

Scottish Coal.—Some 500 men at Calderhead Colliery, Shotts, went on strike for three days last week against a decision to transfer 190 of their number to neighbouring pits because of redundancy, and 2,000 tons of coal were lost. Otherwise production has been uninterrupted by major labour disputes, and outputs have been steady, although still below the target figure. Supplies of coking coal were a little short last week, but deliveries to other priority users have been restored to normal. Gasworks are well situated for fuel at the moment; Durham supplies have now been suspended, and deliveries from Northumberland are expected to be stopped ultimately. Recent exports from East Coast ports have included the usual tonnages for Sweden, Finland, and Denmark—principally industrial sorts. Several cargoes of bituminous gum have been under negotiation on Spanish account, but stocks of anthracite and low-volatile gum have been well cleared, and recent movements were confined to two small cargoes shipped coastwise to London.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—An interesting development on the Welsh steam-coal market during the past week was the resumption of ordinary trading with Spain. Some special cargoes have been sent to this market under a barter agreement, but no coal has been available for ordinary users in that country since shipments ceased early in the war. The present business was in respect of 1,600 tons of Welsh opencast smalls and further inquiries were circulating, though it was reported that the Spanish buyers were more interested in higher-grade fuels. In pre-war days Spain was an important outlet for Welsh coals, and in 1938 took 577,006 tons, which was rather more than half the total shipped by the United Kingdom. Holidays at the Welsh mines will be staggered again this year, and will begin in the week commencing July 12 and end on August 9. Rates of pay for the week have been agreed at 6*l.* 5*s.* for men of 21 and over; 5*l.* for men between 18 and 21, and 3*l.* 15*s.* for boys under 18. Deliveries to France have been on an increased scale in the past week while deliveries to other countries with which a trade agreement has been negotiated were on steady lines. There was, however, a large overseas demand which operators could not meet. Current outputs were largely accounted for by deliveries to the inland section and the demands of the high priority home industries provided a ready outlet for almost the whole productions of the better grades. As a rule, order books were well filled for some time to come with business from these sources. The demand for cokes and patent fuel remained brisk and was not easily met.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that the demand for tin-plates shows few, if any, signs of weakening. Last week, however, the sales to home consumers were a little lower. In the export market, on the other hand, there was a slight improvement and more orders were placed. The position in regard to steel sheets is unchanged; the demand is strong and makers are unable fully to satisfy their customers' requirements. Iron and steel scrap continue to be in urgent demand.

ROYAL AERONAUTICAL SOCIETY.—The following members of the Royal Aeronautical Society have been successful in the recent ballot to fill vacancies on the Council of the Society: Mr. E. J. N. Archbold, B.Sc., A.F.R.Ae.S., Lord Brabazon of Tara, M.C., F.R.Ae.S., Mr. A. V. Cleaver, A.R.Ae.S., Dr. G. P. Douglas, O.B.E., M.C., F.R.Ae.S., Mr. A. G. Elliott, C.B.E., F.R.Ae.S., Mr. J. W. F. Housego, Grad.R.Ae.S., and Mr. W. Tye, B.Sc., F.R.Ae.S.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Iron and steel producers continue to turn out tonnage on as heavy a scale as conditions permit, but customers are pressing for larger quantities than they are receiving. Ironstone supplied from the Cleveland mines is gradually increasing in quantity, but still falls considerably short of requirements, necessitating the extensive use of imported foreign ore. Scarcity of iron and steel scrap is slightly less acute than of late, but consumers continue to press for larger parcels than merchants can provide. Fuel supplies are fairly satisfactory, though users of some classes would welcome larger deliveries than are coming forward. Pig-iron consumers are anticipating larger deliveries in the near future and buyers of finished products are receiving unexpectedly large parcels of commodities which are in strong request both for home purposes and for shipment overseas.

Foundry and Basic Iron.—No ordinary No. 3 Cleveland pig-iron has been produced for a considerable time and the intermittent make, on Tees-side, of a substitute quality suitable for foundry use is slight, so that North East Coast foundry owners are almost entirely dependent on deliveries of pig from Midland blast-furnaces. Parcels from that area are arriving fairly regularly, but are not always adequate for ironfounders' urgent needs. The shortage of heavy iron scrap, due largely to the non-fulfilment of promises of substantial quantities from Germany, also greatly hampers foundry operations. The output of basic iron, though steadily maintained, is barely sufficient for current needs, but some enlargement in the make is possible.

Hematite, Low-Phosphorus and Refined Iron.—Regular users of East-Coast hematite are receiving only just sufficient tonnage to meet their actual needs and there seems little likelihood of an early improvement in the position. Outputs of low- and medium-phosphorus grades of iron are ample for consumers' requirements. Refined-iron manufacturers have a ready sale for their products.

New Blast-Furnaces.—Two large blast-furnaces are to be erected at the Cleveland Works of Messrs. Dorman, Long and Company, Limited, and, it is understood, will be the largest in the British Empire. Each will have an output of 1,000 tons of pig-iron a day. Messrs. Head, Wrightson and Company, Limited, Thornaby-on-Tees, have been appointed consultants for the design of the plant.

Manufactured Iron and Steel.—Branches of industry turning out semi-finished and finished iron commodities are assured of great activity over the present delivery period. The tonnage of pig-iron and scrap reaching the iron foundries are still inconveniently short of requirements, but the position, in this respect, is expected to improve during the summer months. Steel producers are running their plants at as high a capacity as conditions warrant, but the production falls considerably below customers' urgent needs and every effort is being made to enlarge output still further. Larger supplies of semi-finished steel are reaching users from home sources, but parcels of foreign products coming forward are only slight. Billets and sheet bars continue in very strong request. The demand for finished descriptions of steel is increasing. Sheets, railway requisites, shipbuilding material and colliery equipment are being called for in larger quantities than the manufacturers can supply.

THE LATE MR. N. A. ENTICKNAP.—We regret to learn of the death, on May 9, at the comparatively early age of 57, of Mr. N. A. Enticknap, joint secretary since 1943 of the General Electric Company, Limited. Mr. Enticknap joined the audit department of the company in 1910, and, three years later, was sent to Spain as secretary of their Spanish subsidiary. On the outbreak of war in 1914, he returned to England. In 1937, he was appointed assistant secretary, and became joint secretary six years later.

GENERATION OF ELECTRICITY.—The official returns previously rendered to the Electricity Commission and now rendered to the Ministry of Fuel and Power show that 3,744 million kWh of electricity were generated by the authorised undertakings in Great Britain during April, 1948, compared with 3,387 million kWh during the corresponding month of 1947, an increase of 357 million kWh, or 10·5 per cent. During the first four months of 1948, the total amount of electricity generated was 16,470 million kWh, compared with 15,722 million kWh for the corresponding period of 1947, an increase of 748 million kWh, or 4·3 per cent. In future, these figures for electricity generated will be added to the Ministry of Fuel and Power's weekly press statement of coal output, consumption and stocks, and the issue of the present monthly return will be discontinued.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

ELECTRODEPOSITORS' TECHNICAL SOCIETY.—Monday, May 24, 5.30 p.m., Northampton Polytechnic, St. John-street, Clerkenwell, E.C.1. "Continuously Electroplated Steel Strip and Sheet," by Messrs. A. Smart and F. H. Smith.

SWANSEA AND DISTRICT METALLURGICAL SOCIETY.—Tuesday, May 25, 6.30 p.m., Royal Institution, Swansea. Annual General Meeting.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, May 25, 6.30 p.m., Manson House, Portland-place, W.1. Annual General Meeting. "Proposed System in Instrumentation Symbols," by Mr. J. K. Burkitt.

INCORPORATED PLANT ENGINEERS.—*Glasgow Branch:* Tuesday, May 25, 7 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "Power Transmission Problems and the Use of Suitable Couplings," by Mr. C. W. Chapman.

ROYAL MICROSCOPICAL SOCIETY.—*Section of Industrial Microscopy:* Wednesday, May 26, 6 p.m., B.M.A. House, Tavistock-square, W.C.1. "Principles of Interference Films Used in Optical Instruments," by Dr. K. M. Greenland.

INSTITUTION OF ELECTRICAL ENGINEERS.—*London Students' Section:* Wednesday, May 26, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. Annual General Meeting.

ROYAL STATISTICAL SOCIETY.—*Research Section:* Thursday, May 27, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Sampling Theory Applied to Autoregressive Sequences," by Mr. D. G. Champernowne.

ROYAL AERONAUTICAL SOCIETY.—Thursday, May 27, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Wilbur Wright Lecture on "Size in Transport," by Mr. A. Gouge.

INSTITUTION OF ENGINEERING DRAUGHTSMEN AND DESIGNERS.—Friday, May 28, 7 p.m., The Royal Society of Arts, John Adam-street, W.C.2. "Three-Dimensional Engineering Drawing," by Mr. W. E. Walters.

ROYAL SOCIETY OF ARTS.—Wednesday, June 2, 2.30 p.m., John Adam-street, W.C.2. Peter Le Neve Foster Lecture: "Craftsmanship—Summing Up," by Professor A. E. Richardson.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, June 2, 6.30 p.m., James Watt Memorial Institute, Birmingham. "A New Approach to Band Conveyors," by Mr. O. J. B. Orwin.

CHEMICAL SOCIETY.—Thursday, June 3, 7.30 p.m., Royal Institution, Albemarle-street, W.1. Liversidge Lecture: "The Modern Theory of Valency," by Professor L. C. Pauling.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—There was a spurt before the Whitsuntide holidays to complete specific jobs before the works closed down generally from Friday night to Wednesday morning. Considerable arrears of repairs and overhauls of plant and machinery were dealt with during the break. There is no slackening in the demand for steel, production of which, although higher week by week, does not satisfy the requirements of users. All makers of steel products are very heavily booked, but would be able to give quicker deliveries if there were not a shortage of materials. In the edge-tool trades it has been possible to improve the rate of delivery, but in these trades also there is insufficient steel, the shortage of which has necessitated considerable negotiations with the Ministry of Supply, who have promised to deal with the matter. The position is now regarded as more hopeful. There has been a satisfactory maintenance of export trade in edge tools. Engineers' small tools, including high-speed twist drills, milling cutters and reamers, continue to be in very heavy request.

South Yorkshire Coal Trade.—Supplies are short because of the Whitsuntide holidays and some unofficial disputes. Considerable deliveries were made to railways for Whitsuntide train traffic, and a growing weight of steams has been earmarked for export trade during May. More coking coal is needed to satisfy the requirements of the coke-works which are heavily booked in hard coke for the iron and steel trades. Some of the newer opencast sites are yielding very satisfactory outputs, and every section of the market is receiving a higher proportion of opencast coal.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

(*For Description, see Page* 485.)

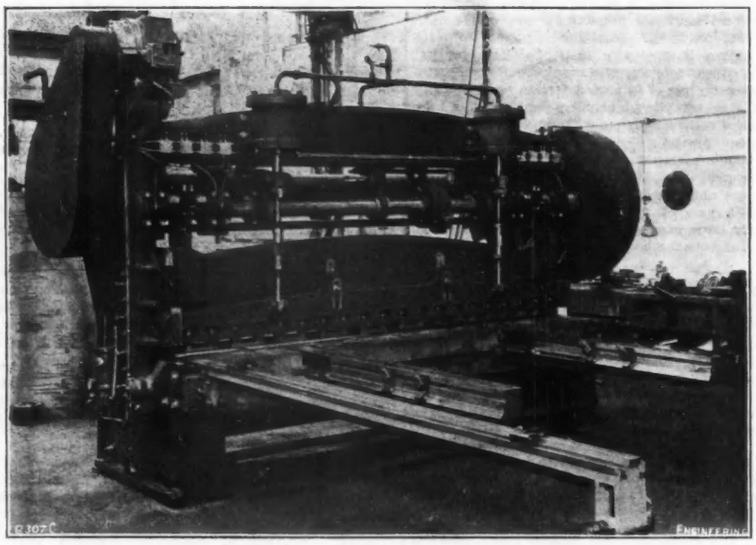


FIG. 29. GUILLOTINE SHEARING MACHINE; MESSRS. BROOKES (OLDBURY) LIMITED.

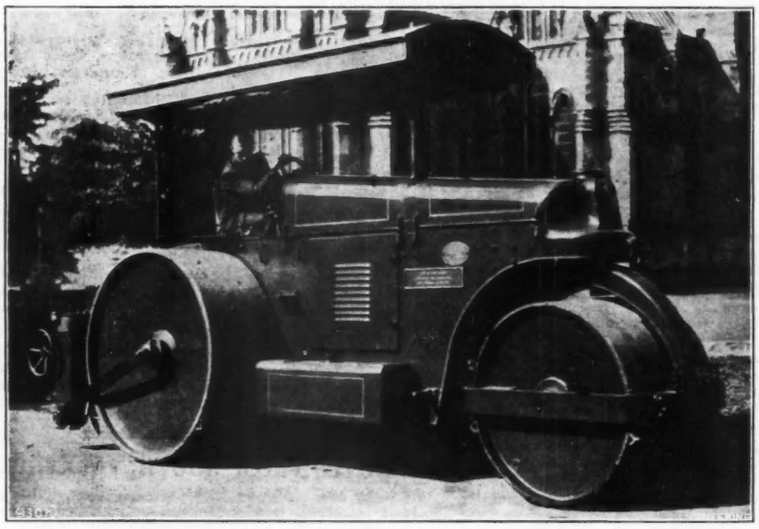


FIG. 30. DIESEL-ENGINED ROAD ROLLER; MESSRS. AVELING-BARFORD, LIMITED.

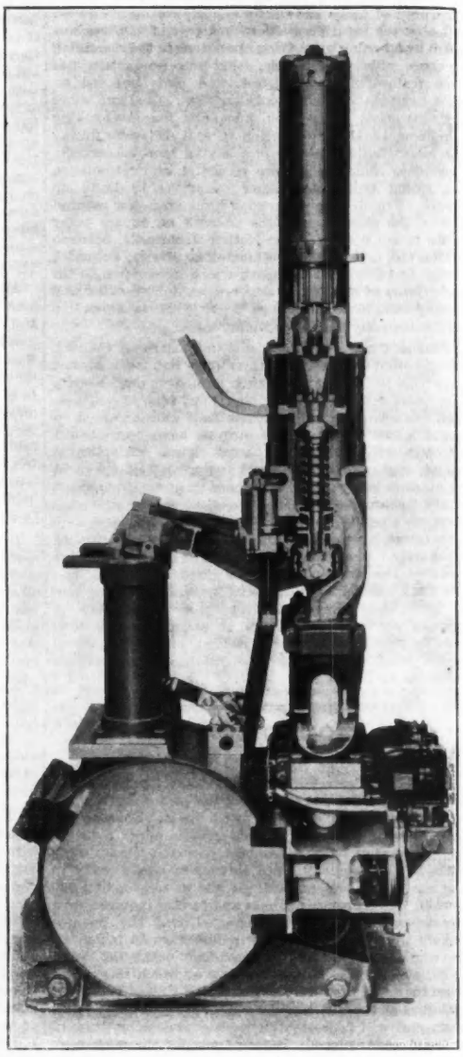


FIG. 31. 500-MVA 11-KV AIR-BLAST CIRCUIT BREAKER; ENGLISH ELECTRIC COMPANY, LIMITED.

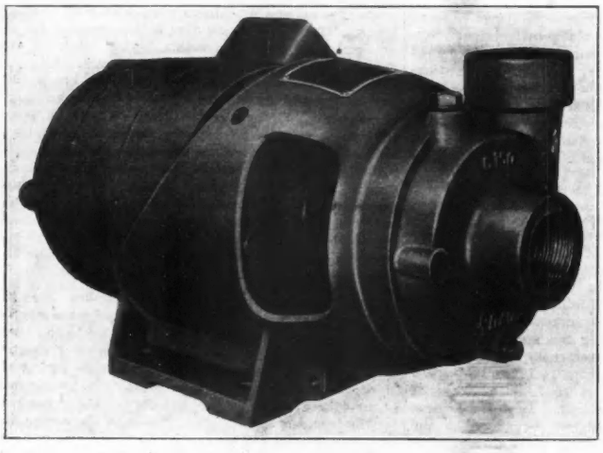


FIG. 32. 1½-IN. ELECTRICALLY DRIVEN CENTRIFUGAL PUMP; GIRDLESTONE PUMPS, LIMITED.

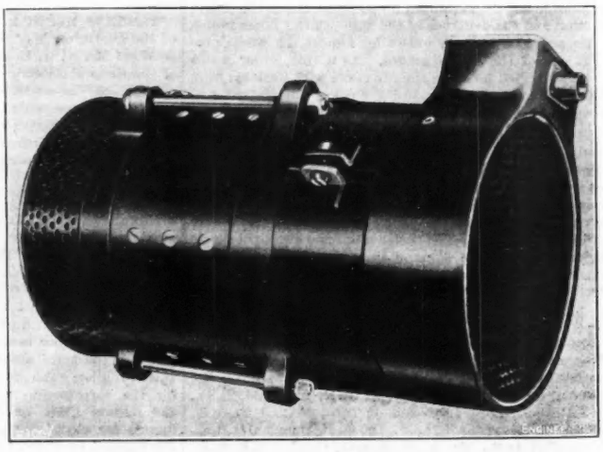


FIG. 33. 400-WATT ROTARY CONVERTER; C.A.V., LIMITED.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, MAY 21, 1948.

VOL. 165. No. 4295.

MECHANICAL FAILURES.

MECHANICAL failures may be due to defective material, unsound design or ill usage, although, in a sense, all these causes are basically examples of human insufficiency. Defective material may result from error or carelessness in some metallurgical process, inexpert heat treatment being a frequent cause of trouble; unsound design is obviously due to inattention or insufficient knowledge; and ill usage arises from ignorance, frequently coupled with good intentions. An example of this latter cause is furnished by the case of a damaged ⅞-in. diameter bolt on a steam-pipe range. Microscopic examination of the material of which the bolt was made showed it to be entirely satisfactory for its purpose, but measurement of the distance between the threads showed that considerable stretch had taken place in the neighbourhood of the shank. Tests were then made to estimate the force required to stretch a similar bolt, a nut being screwed on by a man using a 3-ft.-long spanner with both hands. This resulted in deep cracks forming at two neighbouring threads. A similar operation with a 2 ft. 6 in. long spanner resulted in stretching exceeding that of the original bolt under examination, but with a 2 ft. spanner one man was unable to make the threads stretch permanently. It was concluded that the original bolt had been subjected to treatment equivalent to screwing up with a 2 ft. 6 in. spanner or, alternatively, using a 7-lb. hammer on a 12-in. spanner. "Gross abuse" of this kind may, and does, arise from the well-intentioned object of making a secure steam-tight joint.

This example is quoted from the *Technical Report for* 1938* of the British Engine Boiler and Electrical Insurance Company. In explanation of the fact that the report for 1938 has appeared in 1948, it is stated that, although it had been printed as usual, it was decided to suspend publication at the outbreak of war owing to "the preoccupation of our readers with the National Emergency." Copies of certain articles relating to welding, however, were extracted and issued in a limited number. The publication of the full report is to be cordially welcomed. The documents, of which this is the latest, first appeared in 1922 and constitute a valuable record of mechanical and electrical failures in a wide engineering field, with acute analyses of causes and sound advice bearing on their avoidance. The fact that this report has been issued nine years after its preparation does not detract from its value in any way whatever. The problems and troubles with which it deals are just as much present in 1948 as they were in 1938. The report is referred to above as the "latest" but in the foreword it is stated that "whether reports in similar form will be issued in future years remains doubtful." A very wide circle of engineers will hope that the doubt will be resolved in a favourable way and that this "latest" report will not prove to be the "last." The foreword concludes with a tribute to the late Mr. L. W. Schuster, the chief research engineer of the Company, who was so largely responsible for the matter of these reports and for building up the status which they have attained.

The report contains such a large amount of material covering a wide field that any attempt to deal with its contents in a relatively short article must necessarily be arbitrarily selective. There is, however, one item in its accounts of failures and tests to which reference can hardly be avoided. This is not because the incident which is recorded carries any particularly valuable lessons, but because of its entirely unexpected nature and its illustration of the remarkable results which may follow simple, and apparently relatively harmless, procedure. The incident was concerned with a single-cylinder horizontal solid-injection oil engine which drove an electric generator supplying lighting current to a large brickworks. The cylinder was 13 in. in diameter, the stroke 20 in. and the speed 224 r.p.m. The engine was 15 years old. It was in charge of one of the kiln attendants, whose main duty was to look after the lubrication. Noting one day that the lights were dim, he went to the engine room and found that the engine was labouring and that the centre bearing between the crank and flywheel was overheated. He accordingly stopped the engine by turning off the oil supply from the service tank to the fuel-pump, instead of stopping it, as he should have done, by putting the pump out of action by the hand lever fitted for the purpose. As a result of the method followed, the engine continued to run until the oil in the pipe was used up or the pump had become air locked. The attendant stated that the engine ran for about one minute after he had cut off the oil and then stopped suddenly.

The maintenance engineer was sent for and arrived on the site two hours after the engine had stopped. He removed the bearing cap and found that the overheating had resulted from the uncoupling of the oiling ring; the crankshaft appeared to be in order. He then commenced to bar the engine round to permit inspection of the middle portion of the shaft. Unfortunately, instead of putting the engine on half compression, he barred it in the normal direction of running against full compression. After reaching the inner dead centre he found difficulty in turning the shaft further and accordingly gave two or three jerks at the end of the barring bar. The result was remarkable; there was a violent explosion, the shaft was forced out of its bearings, the two pedestals were broken, the flywheel spokes sheared off and the engine completely wrecked. Investigation of the matter by the insurance company lead to the conclusion that, when the engine was labouring due to the hot bearing, the governor closed in, giving a maximum delivery of fuel oil. This was not completely burned, and after-burning took place in the cylinder with considerable heating and the deposition of soft furry carbon. The engine stopped at the end of the suction stroke, so that the last action of the piston was to draw in a supply of air. This carbon deposit had evidently been smouldering, and was still smouldering when the maintenance engineer barred the engine to the dead centre. Owing to the presence of an excessive amount of fuel oil in the cylinder, an abnormally-high explosive charge was formed and became ignited by the smouldering carbon.

The report contains detailed accounts of some thirty cases, and classes, of mechanical failure with,

* *Technical Report for* 1938. British Engine Boiler and Electrical Insurance Company, Limited, 24, Fennel-street, Manchester, 4.

in many cases, particulars of the metallurgical investigations to which they led. In a number of cases the trouble experienced could be traced back to defects in welding procedure. An example of this kind was furnished by some large pipes in a steam range which failed after five years' service. On a section of one of the pipes received for examination, the metal had been chipped away indicating that a crack had been discovered during a previous examination. It was found that, in addition to the crack developing through the thickness of the metal from the inside of the pipe, there was a ramification of cracks in the chipped-out area. Metallurgical examination disclosed the presence of weld metal penetrating to an appreciable depth in the area of ramified outside cracks, and examination of other portions of the sample, and of other pipes from the range, disclosed globules of weld metal, the majority containing star cracks, disposed indiscriminately around the pipes about 5 in. or so from the ends. The parent metal of the pipes was entirely satisfactory and these incipient cracks were judged to be due to the operator when welding on a flange or branch, hitting the surface of the pipe with the end of his electrode in order to break off the slag. Cracks in the solid steel of the outer surface were extensions of cracks started in the weld metal, the initial cracks being due to contraction of the hot weld metal deposited on to a cold surface.

The report contains a section dealing with accidents due to ignorance or carelessness in the maintenance of plant. A number of the incidents recorded were concerned with electrical machinery. In one case, a 10-h.p. slip-ring induction motor, which drove the hoisting motion of a crane, failed and was replaced by another slip-ring motor of similar horse-power, which was normally used for driving a circular saw. The original motor ran at 720 r.p.m., but the substitute was designed for a working speed of 1,420 r.p.m. When it had been at work for two or three days, the rotor shaft broke. The hoisting motion of the crane was driven by fixed gearing and the speed regulated by a reversing drum controller introducing resistance into the rotor circuit. With the replacement motor running at its rated speed of double that of the original motor, the power output was doubled and the motor was in danger of burning out. Although the load torque was not altered, the rotor was mechanically overloaded by virtue of the fact that it had been designed for an output of 10 h.p. at twice the speed of the original motor and the shaft was intended to carry only half the load torque of that of the original.

Another example of an unwise replacement was furnished by a rotor starter on a 15-brake horse-power three-phase slip-ring motor. Owing to a defect, this was replaced by the starter from another 15 brake horse-power slip-ring motor working on the same supply. To the surprise of the electrician in charge, the substituted starter was completely burned out in a few days. He had failed to realise that a starter is designed for a particular motor to suit the rotor voltage and starting conditions, and it happened that the rotor voltage of the motor in question was considerably higher than that of the machine from which the starter had been taken.

Two examples of mechanical accidents which are recorded in this section of the report concerned the starting of engines. It was recommended that a five-cylinder vertical air-injection Diesel engine with 12-in. cylinders should be barred round for at least one, and preferably for two, revolutions before being started. In spite of this, the attendant started the engine directly on compressed air. A loud explosion was heard and when the air was shut off and the engine opened up, it was found that the liner of one of the cylinders had been cracked previously and that, while the engine was standing, water had leaked into the combustion space. When the engine was restarted, this water was trapped between the piston and cylinder head. The result of this example of carelessness, or laziness, was that the piston was fractured and the liner broken circumferentially all round the underside of the top flange. The main column casting, forming the cylinder monobloc, had also to be renewed owing to the breaking away of the attachment from the cylinder head.

ENGINEERING RELICS IN THE MIDLANDS.

IN our issue of January 31, 1947, we recorded that a meeting had been held in the James Watt Institute, Birmingham, to set on foot an inquiry of a somewhat unusual character. The meeting was organised jointly by the Midland Branch of the Newcomen Society and the Birmingham Common Good Trust for the purpose of inaugurating an appeal "for the collection and preservation of relics and records of the technological history of the Birmingham area and adjacent counties," and was the outcome of a suggestion by the Trust. At the meeting, Mr. George Cadbury, chairman of the Trust, explained the scope of the proposed survey and stressed its urgency; Birmingham, he said, was one of the most fertile regions in the country in the production of engineering inventions, but the district had been denuded already of many historic relics of its activities and prompt action was necessary to locate and preserve, if possible, those which remained, many of which were in the hands of private individuals, some of whom might not be aware that these possessions had any historical value. The Trust had offered to defray the initial expenses of the survey and would consider steps to preserve any valuable material which might come to light.

The meeting was unanimously in favour of the proposal, and, shortly afterwards, the general appeal was issued, backed by representatives of a number of engineering institutions and societies which are interested in the industries of the Birmingham area and the adjacent counties of Derbyshire, Staffordshire, Shropshire, Warwickshire and Worcestershire. The Newcomen Society have taken an active part in the subsequent work of the survey, the honorary secretary of their Midland Branch (Mr. W. K. V. Gale) serving also as secretary of the survey; an association which is the more appropriate as the Newcomen Society originated in the centenary celebrations in 1919 of the birth of James Watt, and Mr. Gale is connected with Messrs. W. and T. Avery, Limited, the present proprietors of the Soho Foundry, formerly occupied by James Watt and his firm, where a number of relics of Watt and Murdoch are still preserved.

It may be admitted now, that some of those who were present at the inaugural meeting, while heartily supporting its objects, were more than a little doubtful whether any appreciable quantity of historical material still survived; sufficient, that is, to warrant the foundation of a museum in which to house it, akin to the industrial museums already formed in Newcastle-on-Tyne and in Sheffield. Realising quite well that, with the present demand for building materials and labour, no early steps could be taken to provide a museum building, nevertheless they agreed that the survey should be undertaken without delay. Obviously, no case could be made out for the erection of a museum and the provision of staff and financial support until it was reasonably certain that enough exhibits would be forthcoming to make the venture worth while; bearing in mind, also, that extensive records and relics of Watt and of Matthew Boulton are already preserved, respectively, in the James Watt Collection at the Birmingham Reference Library and at the Assay Office in the city, in addition to those at the Science Museum, South Kensington.

In fact, according to an interim report on the progress of the survey which has been issued during the past week,* there was an excellent response to the appeal and already a number of interesting items have been located; several are illustrated in the report. At the same time, it is felt that much more knowledge must be available about local trades, works, plant and records than has yet come to light, and the opportunity has been taken, very wisely, to indicate some of the kinds of information that the organisers would like to receive; for example, details of some of the branches of industry, past and present, which have been developed to such an outstanding extent in the area that they are known generically as "Birmingham trades"—the manufacture of pins, needles, pens, buttons, tubes, bedsteads, etc. Under the general heading of "Nails, Chains and Black Country Hardware," it is stated that "some collections of nails and chains exist, but much more information would be welcome"; though, with modest reticence, the report does not mention that Mr. Gale himself has done much valuable work in collecting specimens of the different types of hand-made nails for which the district has been famous for many generations.

Among the larger finds reported there is a hay-stack boiler, now used as a water tank, and in Dudley the inquirers found several cylindrical egg-ended boilers, externally fired; both types were familiar sights in the district not many years ago, but now are rare. Engines include one by Boulton and Watt, dating from 1817, and still in working order; and, at Hawkesbury, there is a Newcomen engine, of unknown date, which has been modernised (relatively speaking) by fitting a separate condenser. Several rotative engines have been reported, mainly of the beam type; among them, two McNaught compounds at Nuneaton—unfortunately, about to be scrapped. It is not quite clear whether these two engines are the same as, or additional to, the two Nuneaton engines mentioned in an earlier paragraph of the report and stated to be of 1799 and 1800, respectively. There are also two Cornish engines at Hednesford, and, at Tipton, a canal pumping engine of 1776, made by Boulton and Watt; the last-mentioned engine, which was referred to in the original appeal circular as a typical example of the kind of engineering relic that it was desired to preserve, is of particularly early date, being the third engine made by the firm for sale.

Other fairly large items of plant include a single-cylinder positive-scavenge gas engine, stated to be "made by the Crossley Premier Co., *c.* 1880"; presumably an engine of J. H. Hamilton's design, made by the Premier Gas Engine Company, as the amalgamation with the Crossley Company was much later. A vertical gas engine of 3 h.p., built about 1872, is said to be preserved at Derby. There are several machine tools, including "a fine face-plate lathe" and "a very early side planer"; and, at Bilston, a power press that is now within two or three years of its centenary. The collection of early weighing machines in the Avery Museum at the Soho Foundry is well known, but the inquiry has disclosed the existence of several other items of importance in this category, notably a weigh-bridge and truck at Derby, built by one of the founders of the Butterley Company in 1799, and a cart weighbridge in Shropshire, dating from 1833. At Wildboarclough, Cheshire, there is a water-wheel and governor attributed to James Brindley, and another water-wheel, at Bellbroughton, Worcestershire, is still in use, driving a scythe-grinding mill. Some early dynamos have been reported, and one of these, an 80-ampere machine installed in Archdale's foundry in 1891, is illustrated in the report; others are a dynamo built by Joseph Tangye in 1882 to light his house, and some original machinery built some 60 years ago by Thomas Parker, one of the founders of the Electric Construction Company.

Dies and patterns used in Matthew Boulton's silverware factory are mentioned; also some dies used for coining. Small tools, early drawings and maps, a cast-iron bolt of about 1790 (with cast threads), and a certain amount of correspondence are other items which the survey has brought to light. So far, therefore, it is clear that the venture set on foot a year ago has been well justified by results; but there must be a great deal more material still untraced, and it is to be hoped that the publicity which the interim report gives to these researches will have the effect of producing further valuable information especially relating to the industries—for example, gunmaking, and the manufacture in Coventry and district of clocks and watches—which are not yet represented. For the time being, the aim is only to collect particulars of items of possible interest; the nature and extent of subsequent action will depend on what the inquiry eventually reveals.

* *Interim Report*, 1948: *Survey of Items of Engineering Historical Interest in the Midlands.* Obtainable from Mr. W. K. V. Gale, 3, Halton-road, Boldmere, Sutton Coldfield, Warwickshire.

NOTES.

WATER-POWER DEVELOPMENT IN SCOTLAND.

On Saturday, May 15, the North of Scotland Hydro-Electric Board, 16, Rothesay-terrace, Edinburgh, 3, published two schemes for developing the water power in Inverness-shire. These schemes cover an area of 309 square miles north-west of the Great Glen; and will produce about 384 million kWh per annum. They will thus provide power for future industrial development in the Inverness-Fort William areas, as well as increasing the electricity available both in the Highlands generally and other parts of Scotland. The first of these projects (Constructional Scheme No. 24) will utilise a catchment area of 151 square miles to produce an average annual output of 170 million kWh. It will consist of a dam, 806 ft. long and 107 ft. high, across the Gearr Garry at the extreme end of Loch Quoich. From the reservoir thus formed, the water will be led to a 20-MW generating station, from which it will be discharged into Loch Poulary on the River Garry. At the eastern end of Loch Garry there will be a dam 1,026 ft. long and 84 ft. high, and from this point water will be conveyed to Invergarry power station on the north bank of the River Garry, near its outlet into Loch Oich in the Great Glen. This station will also have an installed capacity of 20 MW and will operate under a head of 218 ft. This scheme differs from others previously proposed for the same area in that it will develop the waters of Loch Quoich to the east instead of to Loch Hourn on the west coast. It will also provide more compensation water. The second project (Constructional Scheme No. 23) will utilise the resources of a catchment area of 158 square miles in Inverness-shire and Ross-shire for the production of about 214 million kWh per annum. For this purpose, the level of Loch Loyne, which lies to the south of Loch Cluanie at the head of the River Moriston, will be raised by a dam 1,542 ft. long and 61 ft. high, and the water so impounded will be conveyed by tunnel and pipe line to Loch Cluanie, the level of which will also be raised by a dam 2,015 ft. long and 108 ft. high. From this loch water will be led by a tunnel and pipe line to a power station near Ceannacroc Bridge, the capacity of which will be 17·5 MW. This station will also receive water from the River Dee, after it has been passed through a subsidiary power station. Two dams will also be constructed on the lower reaches of the River Moriston. One of these, which will be 367 ft. long and 34 ft. high, will be built near Dundreggan and from the reservoir thus formed water will be conveyed to a 13-MW station. This will discharge into a loch formed by a dam on the River Moriston, about two miles upstream from Invermoriston. This dam will be 658 ft. and 95 ft. high, and will provide a reservoir from which water will be conveyed through a tunnel and pipe line to a 20-MW station at Invermoriston. A subsidiary power station will also be built at Livishie.

THE STEVENS MEMORIAL LECTURES.

A special meeting of the Junior Institution of Engineers was held in the lecture theatre of the Royal Society of Arts on Friday, May 14, to hear the fifth and last of the series of Stevens Memorial Lectures, organised by the Council of the Institution in accordance with the terms of a bequest of the late Mr. W. H. J. Stevens. The chair was taken by the President, Mr. R. A. Riddles, C.B.E., and the lecturer was Dr. J. G. King, O.B.E., Director of Gas Research. Mr. Stevens, who died in 1942 and had been an associate of the Institution for 38 years, left a sum of money to be devoted to the provision of a series of lectures on the general subject of "the better utilisation of coal for the production of oil and petrol." The inaugural lecture, delivered by Dr. King in 1944, surveyed the whole field of the production of tars and oils from coal. Succeeding lectures, at annual intervals, were given by Mr. W. G. Adam, G.M., on "The History and Present Practice of the Tar Distillation Industry"; by Dr. R. Holroyd, on "Processes of Destructive Hydrogenation"; and by Dr. C. C. Hall on "The Production of Oil from Coal by the Fischer-Tropsch Process." In the concluding lecture, under the title of "Coal—Oil—Chemicals," Dr. King reviewed current developments in the production of chemicals from the primary products of the conversion of coal to oil; developments which are of great significance, as he pointed out, because they increase the chance of economic success of the conversion processes by providing final products of superior commercial value. First, however, Dr. King supplemented the third and fourth Lectures by bringing up to date the survey of hydrogenation and synthesis-oil processes. In Germany, during the war, the production of oil by hydrogenation reached 3¼ million metric tons per annum, and the synthesis plants contributed a further three-quarters of a million tons. In Britain, also, there were considerable advances, more than half a million tons per annum of aviation spirit being produced per annum, of very high quality. In the United States, a large-scale process of development is in hand, inspired by the inability of natural oil production to keep pace with the growing consumption. The production of chemicals from coal, Dr. King continued, might be brought about through the synthetic-oil processes, by the separation or secondary treatment of oil products; or through the primary synthesis of a raw material other than oil fuel, such as acetylene; or by the direct conversion of coal. Already, the advances made in the manufacture of petrochemicals were so great that possibly the world situation of the future could be best met by using coal as a raw material for liquid fuel and the more applicable petroleum products for chemical synthesis; the world production of chemicals from petroleum products was reported to be 1,600,000 tons in 1946, or 24·4 per cent. of the world's requirements, though it had been only 5 per cent. in 1940. The immense possibilities in the production of chemicals from acetylene were well known, but their realisation was restricted by the high power cost except where cheap water-power was available; much work had been done, however, and a wide range of products obtained. Of the processes for the direct conversion of coal into chemicals, Dr. King gave two examples. The first, which arose from research into the constitution of the coal molecule, was the production of benzene carboxylic acids by the controlled oxidation of coal, by which process half of the carbon in the coal was converted to acids and the remainder to carbon dioxide. The second method was the preparation of base-exchange material from coal by the action of sulphuric acid, and this also had emerged from researches on the constitution of coal. In conclusion, Dr. King thought that the Institution could feel satisfied that they had done justice to the memory of Mr. Stevens and to the purpose of his bequest, and expressed the hope that the members would find scientific interest in a continued study of the developments outlined. After a vote of thanks to Dr. King had been proposed, and carried by acclamation, the President invited his acceptance of the distinction of honorary membership of the Institution, the certificate of which was presented amid applause.

BUILDING RESEARCH STATION OBSERVERS.

It has long been recognised that there is a large body of knowledge and experience in building practice which for various reasons, notably the widespread nature of the industry, has not been collected and collated so as to be readily available to all those concerned with building. As a result of suggestions put forward some time ago by the Architectural Science Board of the Royal Institute of British Architects, discussions were arranged between representatives of that Institute and of the Incorporated Association of Architects and Surveyors, the Institution of Structural Engineers, the Royal Institution of Chartered Surveyors and the Building Research Station, with the object of exploring the possibility of formulating a scheme which would help to fill this deficiency. As a result of these discussions, a scheme has been drawn up which provides for the appointment of a selected number of professional persons in the industry as honorary observers to the Building Research Station. It has been arranged with the professional institutions that the observers should be appointed by the Station to act in an individual capacity and not as representatives of their institutions. The main objects of the scheme are threefold. In the first place the observers will collect from the industry information and experience available in their area of the country. This information will be collated at the Building Research Station, supplemented, if possible, by the results of research, and then made available to the industry through various building journals and in other appropriate ways. In the second place, the scheme will encourage closer relationship between building research and the personnel dealing with the day-to-day problems of the industry. Thirdly, it will provide a channel by which experience with newer materials and methods of construction can be readily collected, thus enabling conclusions to be drawn regarding their behaviour and suitability in practice, more quickly than would otherwise be the case. As a result of the ready co-operation of the professional institutions, the Station has now appointed 47 professional men working in all parts of the country as honorary observers. It has been considered advisable to limit the number of observers in the first instance and to make the appointments for a period of three years. This will enable the scheme to be kept within manageable limits, while simultaneously allowing a considerable variety of experience to be brought in from time to time.

THE SOCIETY OF MODEL AND EXPERIMENTAL ENGINEERS.

The 50th anniversary of the foundation, in 1898, of the Society of Model and Experimental Engineers is being marked by an exhibition of engineering models which was opened by the Rt. Hon. The Lord Forres in the Exhibition Hall of the Imperial Institute, South Kensington, London, on Thursday, May 13. The Society, which was originally named the Society of Model Engineers, was formed on the initiative of the late Mr. Percival Marshall, who also founded and edited *The Model Engineer*. Its present title was adopted in 1910 to cover the activities of its members in the field of small power engineering. In 1943, various clubs with similar interests were affiliated with the Society, which now has some 650 members, while the membership of the associated clubs now totals over 3,000. The exhibition shows the scope of the experimental as well as the purely model building activities of both present and past members, and it contains many examples of great skill and of exquisite workmanship. Most of the exhibits fall into three broad groups, locomotives, petrol engines (including model motor-boats and cars) and steam plant. Dynamometer equipment for testing models is also shown, and it includes a multi-roller assembly which has been developed to measure the draw-bar pull of model locomotives. Engineer Commander W. T. Barker's scale models of representative marine engines as used during the Victorian era were also on view, as well as models of various types of tramcars, and miniatures of ships and well known buildings. A small horological group included the fascinating Congreve clock, and an exhibit which shows how the effects of radiant heat can be used to sustain a pendulum in oscillation. The exhibition is remaining open until 9 p.m. on Saturday, May 22, and the secretary of the Society is Mr. E. L. Ashton, 20, Pollards-hill West, Norbury, London, S.W.16.

CENTENARY OF JOHN LAING AND SON, LIMITED.—During May and June, the firm of John Laing and Son, Limited—the civil engineering contractors who constructed, among other recent work, the 1¼-mile runway laid down at Filton for the Brabazon I aircraft—are celebrating their centenary. The Laing family belonged to Edinburgh, but moved to Cumberland in the Eighteenth Century. James Laing was born at Sebergham, about 10 miles from Carlisle, and this was the centre of his operations. His son John, who formed the present Company, transferred the business to Carlisle in 1867 and carried out many contracts in that neighbourhood, including the construction of the city's original electric power station. During the 1914 war, numerous large Government contracts were undertaken, including the Gretna Green munitions works and its associated township; and during the recent war the firm were engaged continuously on the construction of aerodromes, factories, and, among other special contracts, the underground headquarters and operations room of Bomber Command, Royal Air Force. They were also one of the principal contractors for the construction of the concrete caissons which formed the "Mulberry" Harbour.

LETTER TO THE EDITOR.

ENGINEERING UNITS OF FORCE.

TO THE EDITOR OF ENGINEERING.

SIR,—I think that Mr. R. H. Young's letter in the issue of ENGINEERING for April 9, 1948, page 352, should not, in turn, go unchallenged. In particular his statement, that "this (producing a mathematical equation containing both force in lb., and mass in lb.) of course, is impossible without employing the subterfuge of a 'constant' which in a strictly mathematical sense is not a constant at all" and that "if use is made of the lb. as a unit of force or weight, the unit of mass cannot also be the lb."

It can be demonstrated that the above statements are true only on condition that we use three fundamental units, the other units being derived in a definite manner. In a four-unit system no such limitation applies. It can also be proved that, if a physical equation connects quantities which have been defined in an independent manner, a coefficient of proportionality must be introduced, which, generally speaking, is a number endowed with dimensions. On the other hand, if we use the equation to define a new unit, we can frame our definition in such a way as to make the coefficient of proportionality equal to dimensionless unity, but there is nothing to compel us to follow either one or the other course.

In a three-unit system, whether absolute (lb.-mass, ft., sec.), or gravitational (lb.-force, ft., sec.), we use Newton's Second Law to define the unit of either force (poundal for the absolute system) or mass (slug, for the gravitational system), hence we write it as

$$F = m a \quad . \quad . \quad . \quad . \quad (1)$$

If we decided to adopt four independent units, those of length, time, mass and force, we should have to write the Second Law in such a way, as not to make $m \times a$ equal to, but proportional to F, or

$$F = \frac{1}{k} m a, \quad . \quad . \quad . \quad (2)$$

k denoting a coefficient of proportionality, endowed with dimensions, and depending on the four units defined independently.

Before proceeding further with this idea, may I be permitted to quote Max Planck.*

"According to Newton's law of gravitation a material point of mass m is attracted by another point of mass μ at a distance r with the force:

$$F = f\frac{m\,\mu}{r^2}. \quad . \quad . \quad . \quad (3)$$

Here f, the gravitational constant, denotes an absolute or universal constant whose numerical value, of course, depends on the units fixed for length, mass and time; moreover, f has the dimensions: $\frac{l^3}{m\,t^2}$. . . If we had not already arbitrarily fixed the unit of mass, there would have been nothing to prevent our choosing the unit of mass, so that $f = 1$. The gravitational constant would then be a pure number and the mass would not be a self-dependent quantity, but would have the dimensions: $\frac{l^3}{t^2}$. The unit of mass so defined is used for convenience in astronomy . . . From this again we see that the dimensions of a physical quantity are not inherent in it, but constitute a conventional property conditioned by the choice of a system of measurement. If this circumstance had always been properly appreciated, a great number of unfruitful controversies in physical literature, particularly concerning that of the electromagnetic system of measurement, would have been avoided."

In the above example a way has been clearly indicated, whereby the number of fundamental units can be reduced to two. To achieve it, we have to set k in equation (2) and f in equation (3) equal to dimensionless unity. Forces would then, for example, have the dimensions $\frac{l^4}{t^4}$, and the independent units would be reduced to two only: length and time.

The choice of the number of fundamental units should be governed by purely practical considerations, and the following two seem particularly important. First, the number of fundamental units should be as small as possible, since otherwise too many equations would have to be written with an additional constant. Secondly, the actual units employed in measurement, in particular those which are most frequently encountered in practice, should be easily represented by invariable standards.

Clearly a two-unit system would not be practical, and in the three-unit systems there is no convenient standard for the unit of force (poundal, dyne) in the one, or, for the unit of mass (slug, kg. sec.²/m.) in the other. Furthermore, the continued use of both systems side by side causes untold confusion, mainly because the same names and the same abbreviations are used to denote two quantities, between which (to quote Mr. C. H. Helmer, ENGINEERING, March 19, 1948, page 280) "the difference is not one of size, but of essential nature."

Now, the first step to introduce a measure of order into our writing, and to make it easier to study engineering subjects, is to introduce separate symbols for the two essentially different units. Shortly before the war German engineers proposed to reserve the designations kilogram, and kg. to the unit of mass, and to call the unit of force 1 kilopond, abbreviated to 1 kp. I would propose to reserve the designation "pound" (lb.) for the unit of force, and to call the unit of mass 1 lamb (after Sir Horace Lamb), abbreviated 1 lm., the "m" in "lm" serving as a reminder of the fact that it refers to mass.

However, this expedient would not remove one final difficulty, namely, whichever of the two three-unit systems is used, one of the two important units cannot be represented by an easily reproducible, invariable standard. The only solution seems to be to suggest the use of a four-unit system, that is to define four independent units, those of length (ft., or m.), time (sec.), mass (kg., or lm.) and force (kp., or lb.). This means that Newton's Second Law must be written as in equation (2), where

$$k = 32{\cdot}1719\,\frac{l\,m}{l\,b} \times \frac{\text{ft.}}{\text{sec.}^2}\left(\text{or} = 9{\cdot}80665\,\frac{kg}{kp} \times \frac{m}{\text{sec.}^2}\right) \quad . \quad . \quad . \quad (4)$$

Such a system is clearly advantageous in thermodynamics, because of the widespread use of specific quantities. If we use the absolute three-unit system, we are compelled to measure pressures in poundals per square foot, which is not acceptable, whereas, if we use the gravitational three-unit system, we are compelled, or should be compelled, to refer all specific quantities to 1 slug—which, of course, nobody does. The four-unit system presents no such difficulties and no confusion is likely to arise, provided we carefully distinguish units of mass from units of force and provided we remember to introduce the constant in equation (2) together with its dimensions equation (4). In effect, the procedure is similar to that advocated by Mr. Helmer, without the need for any "subterfuges."

In translating Professor E. Schmidt's book on Thermodynamics,* I have used a four-unit system throughout. The resulting simplification cannot be fully explained here, but I hope that a case has been made out for at least a discussion on the adoption of a four-unit system. It seems that the matter is of sufficient importance, as the number of letters in ENGINEERING proves, to merit investigation by an independent commission composed of delegates of the various engineering institutions.

Yours faithfully,

J. KESTIN, Ph.D., A.M.I.Mech.E.
Polish University College,
317/25, Putney Bridge Road,
London, S.W.15.
April 26, 1948.

* *General Mechanics.* Translation by H. L. Brose. Macmillan. 1933, pages 45 and 46.

* To be published by the Clarendon Press, Oxford.

THE INSTITUTION OF MECHANICAL ENGINEERS.—The rules for the Associate Membership Examination of the Institution of Mechanical Engineers have been revised, the Council having decided to include Automobile Engineering as an optional subject in Section B.

THE IRON AND STEEL INSTITUTE.

(*Continued from page 475.*)

WE continue below our report of the recent annual general meeting of the Iron and Steel Institute, and now deal with the discussion on two papers presented during the second half of the afternoon session on May 5, by Mr. J. Glen, of the Research Department, Messrs. Colvilles Limited, Motherwell.

CREEP IN STEELS.

The first paper dealt with "Abnormal Creep in Carbon Steels," and the second with "The Creep Properties of Molybdenum, Chromium-Molybdenum, and Molybdenum-Vanadium Steels." In his first paper, the author stated that short-time creep tests at a stress of 8 tons per square inch, and a temperature of 450 deg. C., had been carried out on a series of low-carbon steels containing 0·4 per cent. to 1·5 per cent. of manganese, 0·01 per cent. to 0·15 per cent. of silicon, 0 per cent. to 0·11 per cent. of molybdenum, and with varying amounts of aluminium up to 3 lb. per ton. It was found that manganese, silicon and molybdenum, within the limits examined, reduced the creep rate, and that the abnormal creep resulting from aluminium additions was reduced considerably by these elements. Abnormal creep had been defined as a deterioration in creep characteristics due to de-oxidation practice, involving differences in the amounts of aluminium and silicon employed. It should be borne in mind, however, that this deterioration was only appreciable in normal low-carbon steels when the aluminium addition had been sufficient to give the steel a fine grain-size, as measured by the McQuaid-Ehn test. Thus, with proper control, aluminium could be used as a deoxidiser provided that the steel remained coarse-grained. In his second paper, Mr. Glen stated that creep tests, at different temperatures and stresses, had been carried out on 0·5 per cent. molybdenum, 0·8 per cent. chromium-0·5 per cent. molybdenum and 0·5 per cent. molybdenum-0·25 per cent. vanadium steels, and the effect of carbon, silicon, manganese and aluminium had been determined. The effects of various heat treatments had also been examined. The results all indicated that molybdenum-vanadium steel had essentially the same characteristics as those of molybdenum or chromium-molybdenum steel, but that these characteristics were very much more pronounced. Moreover, the molybdenum-vanadium steel, in the normalised and tempered condition, had creep and ruptnre properties much superior to those of the other two steels tested; it possessed enhanced properties as compared with normal steels at present in use for high-temperature superheater and steam and other pipes.

The discussion was opened by Mr. W. E. Bardgett, who stated that on the question of open-hearth and electric steels, the author submitted data and made several references to the superiority of open-hearth steels. In his (Mr. Bardgett's) view, open-hearth steels might or might not be superior to electric steels depending on the conditions. There were many factors which influenced creep resistance. The next speaker, Dr. C. H. M. Jenkins, said that the question of aluminium addition and of silicon content seemed to be very important. If the oxygen content of all the steels tested were determined individually, the information obtained might be illuminating. The oxygen content of some steels examined at the National Physical Laboratory had been greatly reduced by an aluminium addition, and, where the oxygen content was low, high creep-rate steels resulted. Where the oxygen content was high, the steels showed low creep-rates. This seemed to apply quite linearly to basic open-hearth steels, but not to acid open-hearth steels. The question of whether a steel was "open-hearth" or "electric" was merely one of oxygen content.

Dr. R. W. Bailey said that he had felt strongly for a long time that users were not getting the full possible service out of carbon steels, and if this abnormality could be removed there was a good field of greater usefulness for carbon steel. There had been some dispute as to whether chromium

added to molybdenum steel improved the material, but the author had proved most effectively that such additions did give an important advantage. Mr. Glen had spent a great deal of time on rupturing tests. He (Dr. Bailey) had always felt that the Americans had placed too much weight on rupturing tests, and, in the early days of the war, when we, in this country, had obtained information from the United States, a good deal of it had been in that form and could not be used, because it was creep data which designers required. Latterly, however, American metallurgists had definitely changed over to the point of view held in this country, and were now producing creep-test data which were similar to those obtained here. The effect of tempering on molybdenum-vanadium steel was most important and work he had carried out on this steel, coupled with data now published by the author, had indicated that this steel could be depended upon for the building of steam plants for a long time to come. If the microstructure of this steel were studied, it would be seen to undergo considerable changes, but in spite of this the creep resistance remained high. Dr. H. A. Dickie, who spoke next, said that any contribution which could be made to remove or to minimise the type of hot shortness from which plain molybdenum steel suffered would be of value to the engineering industry. The author had made such a contribution by demonstrating clearly the improvement produced by adding 1 per cent. chromium. His results had shown that the elongation factor was greatly improved and that the life of the steel was considerably lengthened. It would be of value if Mr. Glen would consider, in future work, determining the minimum quantity of chromium necessary to produce these beneficial changes, since the presence of 1 per cent. of chromium—or 0·8 per cent., which was usually employed at present—was not entirely without its objectionable features.

Mr. J. Glen, in a brief reply, said that it had been demonstrated very clearly at the National Physical Laboratory that a casting which was furnace-cooled and tempered had very poor creep properties. Thus, if the molybdeum-vanadium steel were furnace-cooled it yielded bad results; in fact, it was worse, in some respects, than the 0·5 per cent. molybdenum steel. The paper did not deal essentially with the properties of steels at relatively low temperatures; his main object had been to ascertain which steel would withstand the highest temperature without failure. He had obtained a life of over 70,000 hours from the molybdenum-vanadium steel when subjected to a load of 6 tons per square inch at a temperature of 550 deg. C. There was, therefore, some justification for exposing this steel to a fairly high stress at temperatures in that region.

At this stage of the proceedings, the President adjourned the meeting.

Hatfield Memorial Lecture.

By agreement with the University of Sheffield, the trustees of the Hatfield Lecture Fund, the third Hatfield Memorial Lecture was delivered by Progessor R. F. Mehl, of the Carnegie Institute of Technology, Pittsburgh, Pennsylvania, U.S.A., on the evening of May 5, at the Royal Institution of Chartered Surveyors, London. The chair was occupied by the President of the Iron and Steel Institute, Sir Andrew McCance, F.R.S. The lecturer dealt with "The Decomposition of Austenite by Nucleation and Growth Processes." In the course of his lecture he stated that the properties of annealed and normalised steels were determined by the structures formed at high temperatures. The rate of nucleation and the rate of growth occurring in the pearlite structure of steels, with rise in temperature, had been measured, and the growth of the ferrite and cementite lamellæ took place in an edgewise direction. Many of the practical methods at present in use, notably that for the study of the composition of carbides by residue processes, should be capable of improvement. It should also be possible to accomplish more with the metallurgical microscope, while much could be done if new methods of determining the free-energy changes at crystal interfaces could be devised.

Inclusions in Steels.

At the resumed meeting at the Royal Institution of Chartered Surveyors on the morning of Thursday, May 6, the first half of the session was devoted to a joint discussion on three papers, namely, "A Micro-Examination of Eight Steels for the Inclusions Sub-Committee," by Dr. J. H. Whiteley; "The Study of Segregations and Inclusions in Steel by Micro-Radiography," by Dr. W. Betteridge and Mr. R. S. Sharpe; and "Some Thermodynamical Aspects of the Formation of Inclusions in Mild-Steel Weld Metal," by Dr. E. C. Rollason and Mr. E. Bishop. In the first contribution, Dr. Whiteley stated that he had investigated, for the Inclusions Sub-Committee of the British Iron and Steel Research Association, eight low-alloy steels, four of which were of the basic-electric class, three of the acid open-hearth type, and one of the basic open-hearth class. In determining the number of inclusions, counts were made on both lengthwise and crosswise surfaces, it having been previously ascertained from the former, that inclusions not well embedded were liable to be removed in polishing. The results indicated that there was a direct relationship between the number of inclusions in the steels and their combined sulphur and oxygen contents.

The second paper, on the study of segregations and inclusions by micro-radiography, by Dr. W. Betteridge and Mr. R. S. Sharpe, described work carried out in the laboratories of the Aero-Engine division of the Bristol Aeroplane Company, Limited. The authors stated that most of the normal metallic alloying elements could be selectively revealed by a suitable choice of radiation. Non-metallic inclusions, however, could not be identified, in general. Of particular interest was the apparent readiness of manganese to form into sharply-defined segregates which were not easily diffused into uniform distribution, since they were detected even in an overheated steel. Although these areas were apparently quite distinct from manganese sulphide inclusions, the sharpness of their boundaries suggested that they might not be true segregates, being, not merely regions of solid solution rich in manganese, but, in fact, actual separate phases which were not soluble in the matrix. It appeared desirable that the nature and occurrence of these manganese-rich areas, in relation to the composition of the steel, should be explored, and their influence on the mechanical properties determined, particularly in the case of high-tensile steels where small regions of a different composition, and thus a different response to heat treatment, were likely to have a strong effect especially on fatigue strength. Using the selective absorption method with cast materials, not only could segregates in highly-alloyed steels be revealed, but also the actual distribution of the constituents within the segregates could be obtained.

In the third paper, dealing with thermodynamical aspects of the formation of inclusions in mild-steel weld metal, the authors, Dr. E. C. Rollason and Mr. E. Bishop, stated that as a result of work carried out in the research department of Murex Welding Processes, Limited, Waltham Cross, it had been shown that the process of inclusion formation in weld metal obeyed the general principles of thermodynamics. In proving this point, a method had been evolved whereby an estimate of the types and amounts of inclusions to be found in a given weld metal could be obtained very simply, using only the FeO content of the slag and the total manganese and silicon contents of the weld metal. The necessity for complicated and laborious inclusion analyses was thereby obviated.

Mr. H. H. Burton, who opened the discussion, said that the object of the Inclusions Sub-Committee was to discover which inclusions were harmful, either in type or number. Much work had been carried out on the subject; thus, the Sub-Committee were greatly indebted to the Bristol Aeroplane Company, Limited, for the work they had done, which had included a vast amount of fatigue testing. In certain respects, steels which were obviously the "cleanest" had not always turned out to be the best under all conditions of fatigue testing. It was possible, however, that the fatigue results which did not always appear to accord with the normal metallographic examination might perhaps do so rather better if the micrographic technique were supplemented by the methods of micro-radiography described in the paper by Betteridge and Sharpe. With regard to the third paper, if it were possible by studying weld metal to predict accurately what the inclusions would be with a certain type of slag, it might be possible to reverse the process and decide what type of slag must be present to form certain inclusions. This might be of assistance in many other directions.

Dr. F. W. Jones stated that Betteridge and Sharpe had demonstrated that their method could be used for studying segregation in steels and that it was useful for giving qualitative information concerning the variety of compositions of different phases present in complex steels. The method, however, had one limitation. In order to obtain resolution with a fine-grain steel, it was necessary to decrease the thickness of the steel specimen to the same order of the grain size. The smallest grain-size steel in which metallurgists were likely to be able to distinguish between the composition of different phases present was probably in the region of 0·001 in. With present methods, this was the thinnest specimen which could conveniently be made.

Mr. K. J. R. Wolfe said that micro-radiography had shown that the true machinability of hardened and tempered constructional steels, especially under conditions of intermittent cutting, was greatly influenced by the tempering process. It had been found that if the steel were subjected to a second tempering treatment at a temperature approximately 25 deg. C. below that of the first, and this were followed by an oil quench, the true machinability index of the steel would be greatly improved, although the usual mechanical properties were substantially unaffected. Micro-radiography experiments conducted on a nickel-chromium (En. 23) steel indicated that the manganese present showed signs of severe segregation. A preliminary examination also indicated that these manganese-rich areas apparently tended to disperse during the second tempering treatment. After the double tempering treatment, further micro-radiographs showed that the segregates had become less sharply defined and more diffuse; thus they were less hard and consequently less abrasive. This would cause less wear on the cutting tool, but would still permit these areas to act in a manner similar to non-metallic inclusions in a free-cutting steel. Following the authors' statement that these manganese-rich areas "were not easily diffused into uniform distribution," typical samples had been again tempered, this time for 24 hours at 625 deg. C., *in vacuo*, and then oil-quenched. Examination of the resulting structure had shown that the diffusion of these areas was nearly complete. It was difficult to accept the authors' hypothesis that these areas might be separate phases, as it had not been possible to detect any evidence of this by X-ray diffraction methods. There was no doubt, however, that these areas would have properties very different from those of the normal steel matrix.

Mr. H. A. Sloman, said that in their paper, Rollason and Bishop had attempted to predict the amounts and identities of the inclusions in weld metal by the use of thermodynamic data. Owing to the necessity for simplifying the very complex mathematics involved, they had considered only equilibria with five elements, namely, iron, manganese, silicon, oxygen and sulphur. Quite unjustifiably, however, they had omitted to consider the effect of hydrogen and carbon. The gaseous envelope in which weld metal was deposited contained large amounts of both hydrogen and carbon in the form of water vapour and carbonic-acid gas, and there was very strong evidence that the composition of the gaseous envelope affected the constitution of the deposited metal. The authors appeared to infer that experimental work was unnecessary and that, by the use of certain thermodynamic calculations, a sufficiently accurate picture of the inclusions in weld metal could be produced. This might be interesting from an academic point of view, but it did not appear that the method suggested was likely to have any practical use, except to show tendencies of the manner in which inclusions might be formed.

Dr. C. H. Desch, F.R.S., drew attention to the very great improvement in technique represented in the paper by Betteridge and Sharpe. He said that X-ray transmission pictures, almost comparable in definition with low-power photomicrographs were

now obtainable, and, in this way, metallurgists would be able to obtain a good deal more information concerning the character of these segregated materials. Dr. Whiteley's work showed that it was still possible to improve the metallographic examination of very carefully polished specimens, so as to get more information than had usually been obtained. Moreover, there was room for a good deal more attention to be given to microchemical methods of analysis. Using spot reagents on a specimen under the microscope, it was possible to identify even quite small inclusions by the formation of characteristic crystals with certain definite reagents. The next speaker, Dr. L. Mullins, stated that the micro-radiography was complementary to microphotography. Whereas the microphotograph revealed the surface structure, the micro-radiograph provided a shadow picture of a thin slice of the material and it was, in fact, a two-dimensional record of a three-dimensional structure. It was for this reason that the specimen thickness must be comparable with the size of the particles being sought. It should also be emphasised that the X-ray technique was restricted to the revelation of components which differed in their X-ray absorption.

At this stage, the President, Sir Andrew McCance, interposed, stating that owing to the passage of time, he must close the discussion, and for the same reason ask the authors to reply in writing.

(To be continued.)

NOTES FROM SOUTH AMERICA.

THE past few months have witnessed important progress in restoring British trade with South American markets. Following the visits of British trade missions, a comprehensive trade agreement (known as the Andes Pact) has been signed with Argentina, and an early announcement is expected of similar agreements with Brazil and Uruguay. At the same time, the United States is seeking to augment even more the existing close economic ties with Latin America. It is possible that both the Export-Import Bank and the International Bank may grant further important loans to South American countries for basic capital developments, such as communications and hydro-electric projects, and private North American industrial interests are also actively seeking to co-operate, south of the Rio Grande.

South America is likely to be a good market for engineering and other capital equipment for as far as can be seen ahead, because of the many schemes for developing huge natural resources. This is particularly true of Argentina, and the Andes Pact is of outstanding importance to Britain. It aims at restoring Anglo-Argentine trade to that uniquely reciprocal basis which was so mutually valuable in pre-war years. Britain is still by far Argentina's best customer, having taken products worth £94,000,000 in 1947, whereas the United States took only £30,000,000 worth, although, on the other hand, Argentina bought British goods valued at only £26,000,000 against £143,000,000 from the United States. Under the new agreement, the Argentine Government buys the British-owned railways, but there are possibilities that Britain may obtain contracts for re-equipment for the railways estimated at about £50,000,000 over the next five years. In fact, the official Administration Commission for the ex-British railways has already been set up and is expected to send representatives to London to examine possibilities for buying British railway equipment.

Probably one of the chief reasons which influenced the Argentine Government in signing the Andes Pact was that they were anxious to avoid any interruption to supplies for their Five-Year Plan, which, during 1947, came mainly from the United States in the form of capital equipment, such as machinery and transport material, as well as coal. Now, however, the United Kingdom is assisted by the Pact in meeting the competition of foreign rivals in heavy industrial products. As the material for the Plan is purchased abroad through the Government trading agency known as the Instituto Argentino de Promoción del Intercambio (I.A.P.I.), it is gratifying that, under the Andes Pact, the Argentine Government recognise the need for increasing purchases from the United Kingdom by every possible means, and, subject to equality of conditions as regards price, terms of delivery, etc., will give preference to British suppliers in making purchases of materials and manufactured goods for official departments. Also, as regards the present regime of exchange and import control in Argentina, the Government will give the United Kingdom the benefit of "most favoured nation" clauses.

In order to meet Argentina's urgent need of materials for local industries, the Pact also stipulates that Britain will do all possible to ensure the sale and prompt delivery to Argentina during 1948 of certain minimum amounts of supplies, including petroleum products, 2,585,160 cub. m.; coal, 1,000,000 tons; steel (manufactured, etc.), 77,350 tons; tinplate, 34,000 tons; zinc sheets, 2,000 tons; tin, 1,000 tons; lead (manufactured, etc.) 1,000 tons; and agricultural implements, 10,000 tons. So far as concerns the agreed shipment to Argentina this year of 77,350 tons of steel (processed or semi-processed), the widespread constructional requirements of the public works under the Five-Year Plan alone should sustain the present great demand for a long time ahead. The item "iron and steel and manufactures" is Argentina's third largest import, and in 1947 rose to 895,300 tons, worth about 40,000,000*l.*, nearly twice the weight and more than twice the value of the 1946 importation. With reference to the establishment in June, 1947, of an Argentine national steel company, styled "Sociedad Mixta Siderúrgica Argentina," with an authorised capital of 100 million pesos, the Ministry of War announced recently that the Department of Military Manufactures had signed a contract with a United States firm and its Argentine subsidiary, whereby these companies will undertake the planning and technical management of the plant which is to be erected at San Nicolas, in the province of Buenos Aires. It is also stated that the contract establishes no exclusive or preferential clauses regarding purchase of materials or execution of orders in foreign countries, and that all orders will be placed by tender. A Government decree issued recently arranges for the establishment of a smelter for Bolivian tin, under the control of the Department of Military Manufactures. This department is empowered to decide whether the smelter should be operated by a "mixed" company formed for the purpose, or should be placed under the management of a firm already in existence.

Argentina's annual requirements of coal have increased to about 3,500,000 tons, against 2,500,000 tons in pre-war days, when Britain was the chief supplier. The resumption of shipments to the agreed extent of a million tons this year would be a great step forward in the restoration of Anglo-Argentine trade, and already the first cargo of British coal since March, 1944, has arrived in the River Plate. By comparison with coal, oil is cheap in Argentina, but there is not enough of either fuel, and any increases in the fuel output will still probably be less than the increase in requirements. Argentina's production of petroleum had declined in recent years (it averages about 3,400,000 cub. m. per annum) because of difficulties in obtaining oil-drilling machinery and spare parts, but is now rising once more. Under the Five-Year Plan, the Argentine State Oilfields have been authorised to spend about 25,000,000*l.* in sundry development works, and in purchases of equipment abroad.

Although the consumption of coal and oil is not likely to be affected for some time by large-scale schemes of electrification, these are being pushed forward; for instance, the Argentine Secretary of Industry and Commerce recently announced that plans are in hand for the building of a hydro-electric plant at Las Pirquitas dam, on the Del Valle River in the province of Catamarca, at a cost of about 3,000,000*l.* The dam has an estimated storage capacity of 65,000,000 cub. m., and will provide irrigation for an extensive zone of Catamarca. The aqueduct from Rio Tercero to San Francisco, in the province of Córdoba, will be inaugurated shortly. This aqueduct, which is one of the most important in South America, is 166 km. long and has cost about 1,000,000*l.*; it will convey water to eleven intermediate townships.

Deficient transport is South America's chief problem. Argentina's imports of "machinery and vehicles" in 1947 were four times the value of those in 1946, at about 80,000,000*l.*, or 25 per cent. of the total imports. Imports from Britain alone in 1947 of vehicles, ships and aircraft jumped to 11,799,000*l.*, from 4,580,000*l.* in 1946. Many orders have been placed abroad for railway equipment, 'buses and other motor vehicles, aircraft, dredgers, oil tankers, etc., and for vessels to build up the national mercantile marine. The Ministry of Interior has been authorised to place up to 100 million pesos at the disposal of the Traffic Control Commission for the purpose of extending the existing underground railway lines and building new ones in the city of Buenos Aires.

The President of Brazil, at the recent opening of Congress, stated that it was essential to find means of increasing national production by re-equipping transport concerns, augmenting hydro-electric power and oil production. As it has become necessary, therefore, to conserve Brazilian exchange resources to pay for imports of capital goods instead of consumer goods, a recent decree requires that, after May 6, a prior permit shall be obtained for most imports into Brazil. Of available exchange, 75 per cent. will be allotted to cover essential imports, which will undoubtedly include many machinery and transport items. The Brazilian Government has drawn up a project, called the Salte Plan, which adumbrates an expenditure of about 500,000,000*l.* over the five years 1949—53 to develop many phases of Brazil's economic resources. The recent issue of shares by the Cia. Hidro-Electrica do São Francisco (equal to some 5,000,000*l.* sterling) has been fully subscribed. The Brazilian Government provide 50 per cent. of the capital of this concern, which was formed to develop electric power from the Paulo Affonso Falls, where there will be a 440,000-kW power-station, as part of a plan for the industrial development of the São Francisco Valley.

The American consulting engineer called in by the National Petroleum Council to examine the possibility of a pipeline to carry petrol and oil from Santos to São Paulo estimates that the cost would not be less than 1,500,000*l.* He suggests that two should be laid, a 10-in. pipe for heavy fuel oils and an 18-in. pipe for petrol and the lighter oils; and he considers that it may take from eight to ten months to obtain the necessary material and equipment. After completion of the masonry and other work, a further three or four months would be needed to bring the pipeline into operation. Orders are on hand in the United States for 143 cars of various types for the Central Railway of Brazil and 1,000 goods wagons for the Paulista Railway; and orders placed in other countries, but still to be delivered, are said to include a further 317 railway wagons. The first part of an order amounting to 2,000,000*l.* for electric equipment for the Santos-Jundiai Railway (formerly the São Paulo Railway), has been shipped to Brazil. This order, placed with the English Electric Export and Trading Company, is said to cover material for the electrification of 85 km. of line, including 15 3,000-h.p. locomotives, described as the largest so far built in the United Kingdom, as well as rolling-stock. The transmission equipment will be supplied by British Insulated Callenders' Cables, Limited. The Cleveland Pneumatic Tool Company intend to set up tractor assembly plants in Brazil and Argentina. Tentative plans call for an initial local production of about 200 tractors a month, most of the parts being shipped from the United States, and it is claimed that the tractors assembled in Brazil will cost less than similar equipment manufactured in North America.

In Chile, the arrival of a representative of an Italian firm of contractors has revived the frequently-discussed project of building an underground railway in Santiago The Government Development Corporation have been granted a 20-year loan by the International Bank for 16,000,000 U.S. dollars, of which 13,500,000 dollars will be spent on electrification in Chile and the balance in the purchase of agricultural machinery. Electrification has proceeded steadily in Chile, despite the difficulties encountered during the war, and positive results are expected in the near future. The hydro-electric plant at El Albanico—which will provide power to the important industrial zone between Linares and Malleco, including the new steel plant at Huachipato, near Concepción—has one of its four new generators working, and the power-station at El Sauzal is being prepared for its final tests.

SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS FLYING DISPLAY.—The annual flying display and exhibition organised by the Society of British Aircraft Constructors will be held this year at the aerodrome of the Royal Aircraft Establishment, Farnborough, Hampshire, from September 7 to September 12, inclusive. This will be the ninth exhibition and, for the first time since its inception, the public will be admitted during the last two days. As heretofore, the first four days will be set aside for overseas buyers, technicians, and other invited guests of the Society. Flying demonstrations will be given on September 7, 8 and 9, but on September 10 there will be no flying as the aircraft will be grounded so that the technical staffs of aircraft firms, Government departments, etc., can inspect them.

FIRE PROTECTION ASSOCIATION JOURNAL.—With the object of keeping their members informed of the latest developments and trends in fire protection and prevention the Fire Offices Committee Fire Protection Association, have decided to issue a quarterly publication, entitled the *F.P.A. Journal*, the first issue of which has now been published. This contains a section on the principal aims and services of the Fire Protection Association, illustrated data on some recent serious fires at rubber dumps, and several other technical articles. Future issues of the publication will contain comprehensive reports of fires; so as to widen the appreciation of special hazards in industrial processes, and information concerning the latest developments in research over the whole field of fire prevention and extinction. Further particulars regarding the Association and its new publication may be obtained from the Director, Mr. W. H. Tuckey, O.B.E., 84, Queen-street, London, E.C.4.

THE DEVELOPMENT OF THE OPEN-HEARTH FURNACE.*

By SIR ANDREW MCCANCE, D.Sc., F.R.S.

As so often happens in the history of invention, the path of progress for the steel industry was created by a man who was not primarily interested in steel manufacture. William Siemens had taken up permanent residence in this country in 1844, and his earliest interests were in electrical and mechanical engineering, like those of his elder brother, Werner Siemens, who founded the firm of Siemens und Halske. Siemens was a man who possessed a truly scientific outlook and he took great interest in all the scientific developments of his time which was indeed a period of giants, for Joule, Clausius and Clerk Maxwell were actively creating the foundations of the dynamical theory of heat on which all modern scientific thought is founded. The problems of heat conservation and economy were constantly in his thoughts and in those of his famous contemporaries with many of whom he was in friendly contact.

It was a year after his arrival in this country that there was brought to the attention of the Institution of Civil Engineers by the Rev. Dr. Stirling, a minister of Galston, near Kilmarnock, a heat exchanger which he had patented in 1817 and which he termed "a regenerator." Stirling had spent many years trying to perfect a hot-air engine with very little success, the engineering facilities available not yet having reached that state of perfection which was really prerequisite to the success of his idea. However, it is on record that a hot-air engine constructed according to his invention, as ultimately developed, was installed in a Dundee foundry in 1842 and worked for several years quite successfully. Siemens acknowledged his indebtedness to Stirling for the idea of regeneration and his first application was in a regenerative condenser which was applied to achieve greater heat economy in the steam engines then in use.

This first attempt was only a qualified success, owing to engineering difficulties, and it was soon forgotten. His second application was to the heating of billets in the ironworks of Messrs. Marriott and Atkinson in Sheffield—an application suggested by his brother, Friedrich Siemens, which was an immediate success and resulted in a saving of 70 per cent. to 80 per cent. of the fuel previously required for this purpose. This furnace, patented in 1857, used solid fuel which was burned in two hearths on each side of the heating chamber and over which passed the air which had been preheated in the now familiar chequer chambers. It is recorded that at these Sheffield works the furnace was also used to melt steel in crucibles and it was no doubt the difficulties which showed up in these trials that directed Siemens's attention to the problems of steel melting. At any rate he came up against serious difficulties when this type of furnace was applied to puddling or to steel melting, and it was only after his invention of the gas producer and his second patent of 1861 that the regenerative furnace, as we now know it, came into its own and that claims in regard to steel melting were made.

But while the new design of furnace was a success, his steelmaking troubles were by no means over. He had the misfortune to give licences to people with no great perseverance, and, in his own words, "Although two of my earlier licensees, Mr. Chas. Attwood of Tow Law and the Fourchambault Company in France, succeeded in 1865 and 1866 in producing steel upon the open hearth, they did not persevere sufficiently to attain commercial results." There is no doubt that part of these difficulties arose from metallurgical causes, for Siemens's earlier endeavours were directed towards making steel by oxidising molten pig iron with iron ore, and the duration of his process, coupled with the then uncertainties of furnace-temperature control, led to failure of the brickwork. These failures had a bad effect on his chances of success, which were still further depressed by the failure of a pirated design of regenerative furnace installed at Woolwich Arsenal but with which he had nothing whatever to do. Indeed, he had such difficulty in getting people interested in his process that on his own account he was forced to start the Sample Steel Works at Birmingham in 1865 for demonstration purposes. This was at first a crucible steelworks, but in 1867 an open-hearth furnace was added.

In the meantime the whole outlook for open-hearth steel had been changed by Pierre Martin at Sireuil. He had taken out a licence in 1864, and by diluting the carbon in the pig iron with wrought-iron scrap before starting to remove it with ore, and by the use of a silica-sand bottom, had quickened up the process and produced good quality steel in a furnace of 1-ton capacity. Martin took out a patent for his process in 1865, but its validity was immediately challenged by many who claimed to have anticipated it and after some years of lawsuits which exhausted his resources he retired from the steel trade, which he had helped to create, a disappointed man. No recognition was given to him until his long life was nearly over and his gratification at receiving the Bessemer Gold Medal from this Institute in 1915 came to him only a few days before he died at the advanced age of 91.

The reasons why cold-metal practice was specially appropriate to Scottish conditions was due to the limited native ore deposits and the need to import a large proportion of the blast-furnace ore, together with the presence of large consuming industries like shipbuilding and engineering which were scrap producers. At the same time, a substantial export of finished steel was carried on and acquaintance with foreign trade and connections and with shipping interests directed attention to the possibilities of scrap importation which was developed in a large way. Even in the years between 1930 and 1940 the Scottish market took 50 per cent. to 60 per cent. of all the steel scrap imported into the United Kingdom.

When Siemens started his Sample Steel Works at Birmingham in 1866 for making steel to demonstrate the success of his regenerative furnace, his one demonstration model had a capacity of 24 cwt. At Landore, and later at the Hallside Works of the Steel Company of Scotland, the furnaces had capacities of 4 tons to 6 tons, although within a few years larger furnaces of 10 tons to 15 tons were constructed which produced 150 tons to 180 tons per week. At this stage, however, there was a pause in the rate of growth of furnace capacity, undoubtedly occasioned by the desire to gain experience both in the engineering construction of steelworks plant and in the metallurgical control of steelmaking operations. There was no lack of inventiveness in creating new designs of handling equipment, nor lack of variety in the methods proposed for dealing with these larger quantities of liquid steel, but the state of the art was still dominated by the principles which Bessemer had introduced in the layout of his own works for the same purpose.

The charging of all furnaces was carried out by manual labour and it was accepted that on the average a 10-ton to 15-ton furnace was a large enough proposition to tackle by hand charging. It was not until the period 1885-95 that the mechanical equipment of open-hearth plants began to take on its own individual characteristics, and melting shops began to assume that appearance which is now so familiar, for it has changed little since then. The first step in this new process was the mechanical charger, introduced almost simultaneously by Wellman in the United States and at Witkowitz in Austria. Originally worked hydraulically, it was changed within a few years to electrical operation. Mechanically-operated doors and, rather surprisingly, the water-cooling of doors, were rapidly introduced into American designs which originated during this period. In considering the much slower introduction of such mechanical aids to production into British works, it must not be forgotten that American climatic conditions played no small part in their speedier adoption in that country, the hotter summers making the heavy work of charging furnaces very exhausting.

It was stated at the time that the introduction of mechanical charging increased the output by 11 per cent. over that with hand charging. The effect of these improvements was soon noticeable and furnace capacities began once more to increase, the average size at the beginning of the century being 30 tons to 40 tons, although larger furnaces had also been built. While the tendency of the times was towards expansion, the gain in production from the increase in capacity was as yet doubtful since the smaller furnaces of 20 tons to 25 tons were giving, in proper hands, four charges a day against two charges a day from a 50-ton furnace. This situation arose from the fact that in their application the principles of combustion were not as yet understood, and the larger furnaces were relatively less efficient in this respect than the furnaces of smaller capacity.

Naturally, this state of affairs stimulated investigation and invention and there followed a period of restless change in furnace design in the hope that the thermal performance of the furnaces could be improved and the causes of poor performance determined or removed. Some of these efforts are of considerable historical interest since they indicate that a few of the limitations of the open-hearth process were already clearly defined in the minds of the metallurgical authorities of the day and that they also had clear ideas how to overcome them, even if they were not always successful. Many efforts are buried in the technical journals and patent applications of the time, but there was no success to change the trend of thought concerning large furnaces. In consequence, progress slowed down and even by 1910 in Britain almost 70 per cent. of the 535 open-hearth furnaces existing were still of 40 tons capacity or less, while in Germany the preference for the smaller furnace was such that 87 per cent. of the then existing units were less than this.

Faith in the benefits arising from large capacity was not completely dormant, however, for in 1908 D. Colville built acid furnaces of 100 tons from which an output of 1,100 tons a week was obtained, and in America a furnace of 160 tons had made its appearance. Effort was concentrated on the combustion problem and many new designs of port were tried out, some of which, like the water-cooled port, have now become standard practice. It was not until after the first world war that the benefits from these technical improvements in construction and practice were realised, for by that time economic conditions and high labour costs together had made more intensive production from steel furnaces and rolling mills an imperative necessity.

It must be admitted that the design of melting furnaces is still entirely empirical and based on experience, and that even the practical rules used by furnace builders to determine the dimensions for a specified furnace capacity show considerable diversity when compared with one another. There is little room for variation in the determination of the cubic capacity of a bath to hold a given weight of steel, but thereafter the area of the bath is generally fixed by allotting anything from 2 to 6 sq. ft. of hearth area per ton of steel, or by the inverse process of first fixing the depth of the bath from previous experience of the behaviour of similar furnaces. In either case there is ample latitude for exercising individual judgment and few of us have not experienced the disappointment of building furnaces the performances of which fell short of expectations.

The practical relation where there is least disagreement is the ratio of length to breadth of the bath, and for most modern furnaces this lies between 2·8 and 3·0. It is controlled by the burning characteristics of the gas flame and limited by the desire not to have too long a travel of the charging-machine ram, and consequently not too broad a furnace chamber within which the ram and box have to work. It is accepted that the depth of the bath is an important factor in determining the production rate, since heat is transmitted to the charge mainly through the upper surface by radiation from the furnace walls and flame.

With this in mind it is a simple matter to deduce a rational basis for dimensioning the hearth by purely dimensional reasoning. The principle could be called that of thermal similarity in which the time to reach a stated temperature at the lowest point of the hearth would be the same for all furnaces irrespective of their charged weight. The charge can be compared to a flat slab of thickness d which is absorbing heat at a constant rate from its upper surface. The heat will flow in from the surface and will create a temperature distribution within the slab which will be constantly changing but at any instant there can be mapped out the contour line for a given temperature T_1, such, for instance, as a temperature near the melting point of the material of the slab itself.

The Open Hearth Committee, in 1938, rated furnaces according to their hourly production rate per 100 tons of capacity, but this is merely equivalent to the number of casts per week. On a continuous week of 168 hours if N charges, of W charge weight, are obtained, the hourly rate will be N W/168, and if this is expressed per 100 tons of capacity:

Hourly rate per 100 tons capacity

$$= \frac{N\,W}{168} \div \frac{W}{100} = \frac{N}{1{\cdot}68}.$$

An hourly rate of 10 tons is equivalent to 17 casts a week—by no means an impossible figure. There are 225-ton furnaces in America using oil-firing and 52 per cent. of hot metal giving this result, and a 90-ton gas-fired Venturi furnace, with cold charging, at Glengarnock, has also reached this target when scrap was of better quality than it is unfortunately to-day. But it must be admitted that with the large tilting furnaces which are necessary for working the high-phosphoric pig irons of Britain such a high rate is unattainable at the present time. Nevertheless, the mere possession of a target figure has usually been in itself a sufficient incentive to technicians.

(To be continued.)

* Presidential address delivered at the 79th annual general meeting of the Iron and Steel Institute, held on Wednesday, May 5, 1948. Abridged.

HINTS TO OVERSEAS BUSINESS VISITORS.—The Board of Trade announces that its booklets on "Hints to Business Men" who are proposing to visit Australia, British East Africa, Denmark, France, Norway, Spain (including the Balearic and the Canary Islands) and the United States have now been reprinted. United Kingdom business men visiting these countries on export business can obtain copies of the booklets on application to the Export Promotion Department, Thames House North, Millbank, London, S.W.1.

LABOUR NOTES.

THE writer of the editorial notes in the May issue of the Amalgamated Engineering Union's *Journal* says: "A clumsy attempt is being made to upset the work of the Government in dealing with industrial and commercial restrictive practices in the Monopoly Bill. The Tory-Liberal Opposition in the House of Commons dare not identify themselves as defenders and apologists of monopoly practices by voting against the Bill; instead, they try to discredit it and the Government by protesting that the Bill does nothing to stop what they call the restrictive practices of trade unions. One answer to this, of course, is that in legislation aimed at the suppression and elimination of price rings, trusts and cartels which deny the principle of free competition sacred to the system of private enterprise, the practices and rules of the trade unions are quite beside the point. They have nothing to do with the case."

"This union," the writer of the notes goes on, "gave up many important safeguards of its members' interests in the engineering shops: safeguards affecting the skilled crafts, dilution of labour, overtime, wage scales, the position of trainees, demarcation problems, the performance of skilled operations by unskilled or semi-skilled and also female labour. For every one of these workshop practices and rules, this union could, and will, make a strong fight as necessary measures for the protection of its members against exploitation in periods of trade depression, short-time employment, wage-cutting—and we will add—the sometimes stupid autocracy of employers and managements."

Continuing, he says, "In relaxing these pre-war customs of the workshop, however, this union took the sensible precaution of having every departure from rules and customs recorded. Our system of registration was generally adopted by the other unions, and all the changes that were made were covered by the Government's pledge and the employers' promises that the unions could claim the restoration of pre-war practices when the war terminated. Legislation embodying the Government's pledge was enacted. The only important question left open in the 1942 Act was the date of bringing it into operation. The original intention was to bring the Act into force on December 31 last. By agreement between the Government and the two sides of the National Joint Advisory Council, it was decided to postpone the date for one year. Automatic restoration of pre-war practices is not envisaged, and provision is made for modification or waiving of any particular practice by negotiation between unions and employers, and for arbitration in disputes about restoration."

According to returns received at the head office from branch secretaries, the membership of the Amalgamated Engineering Union at the end of April was 826,415—an increase of 5,728 compared with the position at the end of March. During April, 5,650 members received sick benefit—a decrease of 487—and 20,297 members superannuation payments—an increase of 51. The total number of unemployed members was 3,753—and increase of 676.

Mr. Tanner has been re-elected President of the Amalgamated Engineering Union on the first ballot. He polled 41,706 votes, while the total votes of five other candidates was 30,022. Mr. Tanner's new term of office begins on September 9 and is for three years.

The Ministry of Labour's "Information Service" states that 63,000 Polish persons have now been placed in employment in this country. Of these, 10,660 have entered building and civil engineering, 7,31f are employed in agriculture, 6,759 are helping to produce coal, and over 5,000 are working in various branches of the textile industry. Others are employed in smaller numbers in a wide range of industries and occupations. It is added that officers of the Ministry recently reported that employers in the Midland Region are practically unanimous in expressing satisfaction with the work of Polish nationals in their employment.

At a recent convention of the American Federation of Labour, the delegates unanimously authorised, on the recommendation of the executive council, the immediate formation, within the American Federation of Labour, of a new organisation, to be known as "Labour's Education and Political League," with the responsibility of educating employees to protect their interests on the political front and to meet adequately the challenge of "reactionary anti-Labour lobbies and combinations" and the wave of anti-Labour laws in Congress and in the different States. The duties of the League will be (1) to acquaint employees of the United States with the economic and political policies of the American Federation of Labour, and (2) to prepare and disseminate information concerning the attitude of candidates for nomination and for election to federal offices, with particular reference to their attitude towards the political and economic policies of the American Federation of Labour. The League was authorised to devise means for the raising of the necessary funds to conduct its affairs, to engage its own staff, and to take any other action considered advisable to further its objectives.

The number of stoppages of work arising from industrial disputes in the United Kingdom reported to the Ministry of Labour and National Service as beginning in March, was 190. In addition, 16 stoppages which began before March were still in progress at the beginning of that month. The approximate number of persons involved during March in these 206 stoppages, including persons thrown out of employment at the establishment where the stoppages occurred, though not themselves parties to the disputes, is estimated at 63,000. The aggregate number of working days lost at the establishments concerned, during March, was about 228,000. Of the stoppages of work through industrial disputes known to have been in progress at some time in March, the coal-mining industry accounted for 111, involving nearly 21,000 persons and resulting in an aggregate loss of 46,000 working days.

Official figures relating to the coal-mining industry, indicate that in the week which ended on May 8, the output was 4,126,200 tons (3,848,000 tons deep-mined and 278,200 tons opencast). The total was short of the required target figure of 4,220,000 tons in a five-day week. Output per man shift at the coal face in the week which ended on May 1 was 2·88 tons, compared with 2·92 tons in the previous week. Voluntary absenteeism among miners at the coal face was 7·12 per cent., compared with 8·18 per cent. in the week which ended on May 1.

Mr. T. E. B. Young, production manager of the National Coal Board, who has been on a visit to the United States, expressed the opinion on his return to this country last week that the only solution of the problem of Britain's coal industry was more work. In order to get more work done, he suggested that there should be more incentives for miners; such as bigger rations and commodity dockets based on attendance.

EFFECT OF NON-CONTACT EXPLOSIONS.

(For Description, see Opposite Page.)

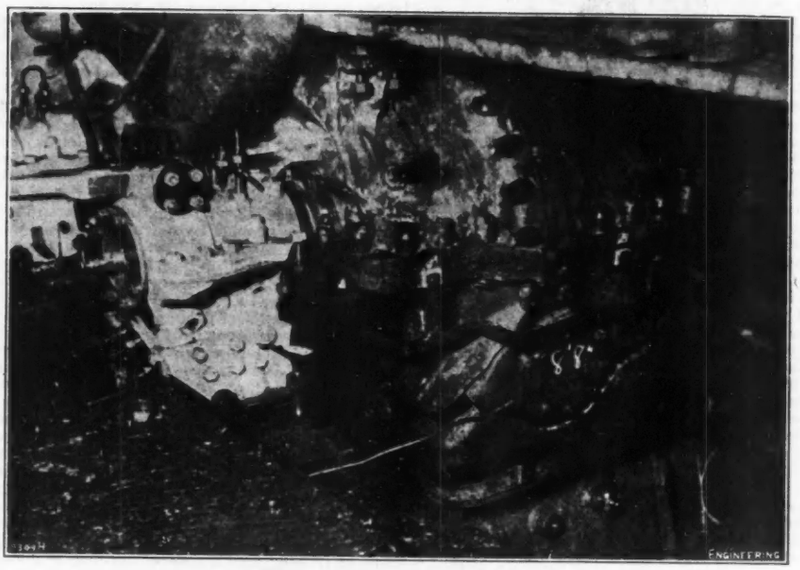


FIG. 8. LOW-PRESSURE TURBINE OF SLOOP.

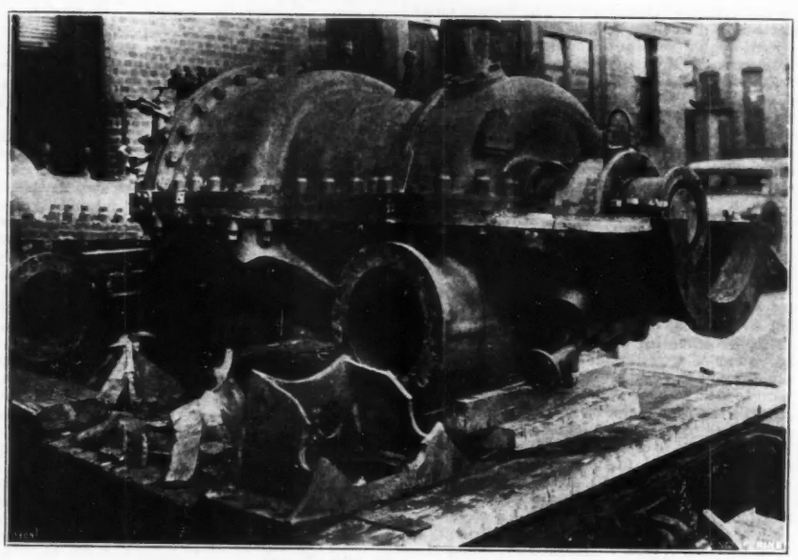


FIG. 9. LOW-PRESSURE TURBINE AFTER REMOVAL FROM SHIP.

EFFECT OF NON-CONTACT EXPLOSIONS.

FIG. 10. TURBINE OF DESTROYER IN WHICH SLIDING FEET HAVE FAILED.

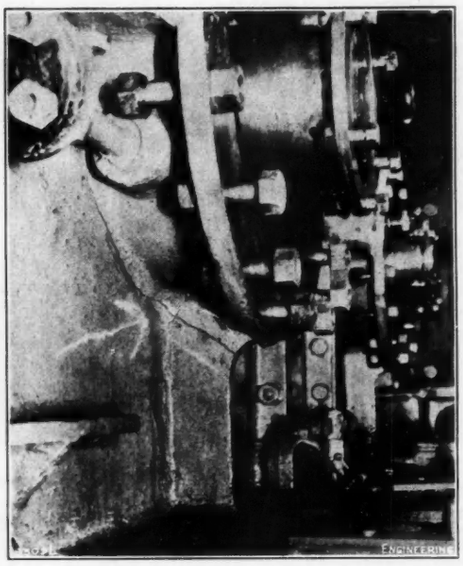
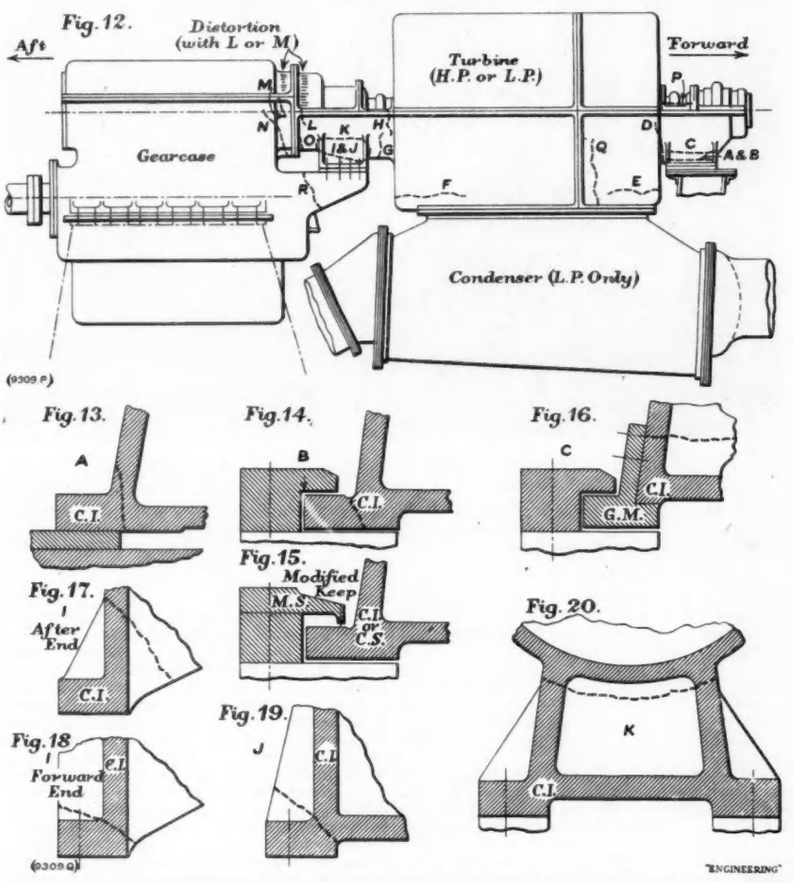


FIG. 11. GEARCASE OF SLOOP.



MAXIMUM-DEMAND ALARM AND INDICATOR.—An instrument, recently introduced by Messrs. Ferranti, Limited, Hollinwood, Lancashire, has been designed to give audible or visual warning that the permitted maximum demand on a three-phase system is being approached. It consists of an integrating meter and a pointer, which can be adjusted to indicate a predetermined maximum load. There is also a re-setting mechanism, which is driven by a synchronous motor, and a pair of contacts, through which connection is made to a warning bell or lamp. The load is integrated during each five minutes in the 30-minute demand period, and a warning is given if the average load thus obtained exceeds the setting. The amount that the load must be reduced can then be ascertained from the reading on a 13-in. dial. The contacts are designed to carry a current of 5 amperes at 230 volts, while the burdens of the current and voltage coils are 0·5 volt-ampere and 3 volt-amperes, respectively. The alarm can be used on either three-wire or four-wire systems, and may be calibrated either in kilowatts or kilovolt-amperes over a limited range of power factors.

EFFECT OF NON-CONTACT EXPLOSIONS ON WARSHIP MACHINERY DESIGN.*

By COMMANDER (E) A. D. BONNY, R.N.

(*Continued from page* 479.)

THE normal turbine is ill-suited to withstand shock forces, and, with the cast-iron construction in general use at the beginning of the war, many turbine units were wrecked by the magnetic mine and near-miss bombs. Typical damage is shown in Figs. 8, 9, 10 and 11, on this and the opposite pages, while Figs. 12 and 13 to 20, show diagrammatically the various types of damage that have occurred. Since a large proportion of the damage was due to the decelerating forces acting on the feet, it is possible to make considerable improvement by fitting yielding keeps to the sliding feet and by adding resilient decelerating washers under the nuts of holding-down bolts, while damage to the gearcase joint was also minimised by reducing the number of bolts and fitting stretching lengths.

The general abolition of cast iron was the other obvious step, and, as far as possible, turbines were either fabricated or made from cast steel. Even so, it was doubtful if it would be possible to design the turbines to withstand the full shock effect in view of the distance of the feet from the centre of gravity, and a rigid resilient mounting is therefore being fitted under the feet. With this mounting, a severe shock will cause a temporary deflection of, say, $\frac{1}{4}$ in. at the end of the turbine remote from the gearcase and a lesser deflection at the gearcase end, but the flexible coupling should be capable of taking up this momentary misalignment and continue running at reduced speed, should a permanent deflection be left.

In figures issued in 1941, a sideways acceleration of $5g$ only was given, but higher figures have been worked to for electrical machinery, and it is clear from experimental data that considerable accelerations in athwartships direction (and also fore and aft, for items mounted on bulkheads) may be met with from relatively shallow explosions, such as from near-miss bombs, particularly by items mounted on brackets on or near the side of the ship; and it is desired to work up to a figure of $60g$ where possible. In a large proportion of machinery with a low centre of gravity relative to the holding-down arrangements, this sideways force does not raise many difficulties, it being necessary only to ensure that the shear stress in the holding-down bolts is not greatly in excess of the elastic limit—some plastic shearing being probably acceptable—and that, under this stress, the bedplate does not fracture at the bolt holes.

With the vertical type of machine, where the centre of gravity is well above the feet, the sideways forces result in an overturning moment which may give

* Paper read at the Spring Meeting of the Institution of Naval Architects, held in London, March 17 to 19 1948. Abridged.

EFFECT OF NON-CONTACT EXPLOSIONS.

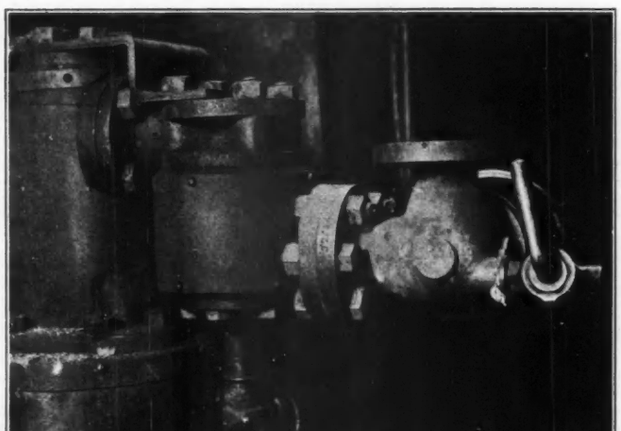


FIG. 21. FRACTURED GOVERNOR VALVE-CHEST.

FIG. 22. GENERATOR BEDPLATE ON RESILIENT MOUNTING.

excessive stresses in the holding-down bolts, as shown in Fig. 23, on this page. This can best be overcome by lifting the holding-down flange to a position nearer the centre of gravity or widening the base; but, where this is impracticable, it is probable that a slight reduction in g value can be accepted, since the machines are generally self-contained and have considerable support at various levels from pipes, etc., while stretching of the holding-down bolts, if not excessive, should not cripple the machine. In this case, the machine as a whole, but without the holding-down bolts, should be capable of withstanding the stated acceleration, the feet must be stronger than the holding-down bolts, and the bolts should be able to withstand the acceleration in shear without exceeding the yield point. Adequate stretching lengths must be provided.

One of the first requirements was to modify the existing machinery in ships to minimise the risk of damage from shock. Since major alterations could not be made, all that was generally possible were makeshift arrangements. These consisted of the alteration of existing chocks and the addition of extra chocks—in many cases, of wood—under the main mass, or the webs supporting it, so that the forces were transmitted more directly. Overhanging masses had separate supports arranged or were bracketed on to the main body (though even this was not always sufficient, see Fig. 21), while the feet were protected by the provision of stretching lengths on the holding-down bolts, placing flexible washers under the nuts, and alterations to keep so that they would yield under the shock forces anticipated. Some idea of the value of these modifications can be gathered from reports of 29 ships fitted with yielding keeps to the turbine feet and subjected to shock; in 11 cases, the keeps yielded and the turbines were not damaged, in eight more half the keeps yielded sufficiently to save the turbines, and in the rest they afforded insufficient protection and the turbines were fractured.

Shock is not the only criterion of design, and it may not be reasonably possible to make a machine for a given purpose capable of withstanding the maximum probable shock forces. In these cases, although the design has covered shock as far as possible, it may be necessary to find means of reducing the shock forces. The simple and obvious solution is the insertion of some form of resilient mounting between the machine and its seating. The machine and its mounting is then a simple spring system, and is acted on by a disturbing force of a period which can be assessed from the experimental results and which is heavily damped after the first half-cycle. Taking any suitable approximation to the force, it is fairly simple to obtain the forced vibration of the spring system that will ensue. In such cases, where the period of application of the load is of the order of one half-cycle only, it is necessary to reduce the frequency of the item on its mounting to be one-half to one-third of the frequency of the applied force if a reduction in acceleration is to ensue.

Equally, the frequency of the machine on its mounting must not equal that of any other disturbing forces likely to be met with in the ship itself, such as the propeller or out-of-balance forces. Since the disturbing force has a frequency of the order of 100 cycles per second and the propeller (assumed three-bladed) of about 15, it is seen that a frequency of between 25 and 35 cycles per second should be satisfactory.

FIG. 23. EFFECT OF ATHWARTSHIP ACCELERATION ON GENERATOR.

In many cases, it is not desirable to mount machinery on a simple resilient pad, since misalignment may result or the out-of-balance vibration may be excessive, and two alternative types of rigid/resilient mountings have been used for these cases. The first of these comprises shearing devices consisting of metal sleeves of form that fail in shear at a predetermined load. These are fitted in combination with resilient pads and ensure that the machine is rigid until, under shock conditions, the load exceeds a certain value; the device then shears and the machine is thereafter resiliently mounted. The second type consists of corrugated plates of iron which crush uniformly under a given load. These again have resilient pads in parallel with them and also absorb energy in crushing.

The shearing devices did not prove highly satisfactory in service, as it was found that, owing to the variations in the forces at different parts of a machine, the devices did not all shear simultaneously and caused excessive bending moments and fractures at the unsheared supports, as shown in Fig. 22, on this page. The corrugated plates are considerably more satisfactory in this respect, since the variations in deflection of different parts of a given machine are smaller; but, nevertheless, relative deflection will occur both between the machine and its seating and possibly between parts of the machine itself, and consideration must be given to this before fitting such mountings. With all these mountings the resilient pads are designed to bring the machine back approximately to its original position, except for any permanent set due to excessive loading. Further, the resilient pads themselves may be liable to creep under permanent loading and cause misalignment. The fitting of rigid/resilient mountings needs care if good alignment is to be maintained, and a high standard of accuracy in the plates and seatings is required.

For this particular purpose, a spring is required that will deflect, say, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. under a load of, say, 40 times the weight of the machine. The material must have a sufficiently long life and resistance to abrasion, oil and heat, and not be subject to creep under prolonged loads. A fairly high damping factor is also useful in preventing resonance conditions and also in absorbing part of the energy transmitted. Since weight is an all-important factor, a simple rubber pad loaded in compression is generally the most suitable, the strain energy stored per unit volume being greater than in a spring involving bending stress. Steel springs are not satisfactory for this reason, and are cumbersome. The use of a plain compression mounting also avoids any bottoming effects with a sudden sharp rise on the accelerations.

Many types employing rubber in shear have also been suggested, but this involves considerable reliance in the bonding of metal to rubber, which, in view of shipboard conditions, is undesirable unless any appreciable advantages are gained. For heavy items, a fairly hard rubber is desirable to keep areas reasonable, and types such as Dexine 118 or Walker's Questo, having a Shore hardness of 80 to 85 deg., are suitable. With these, the compression curves are fairly straight up to 30 to 40 per cent. compression, when they gradually steepen. If noise suppression is also important, or when dealing with light and fragile parts, a much softer rubber is needed. Deterioration of the rubber is a

problem, and, though coated with oil-resisting varnish and fitted in oil shields, its life under adverse conditions is not good. The exercise of a little care in design would, however, obviate much of this.

In theory, all that is required is to obtain a mounting of a known frequency when loaded with a known mass, but the use of material such as rubber leads to further complications in that the load-deflection curve is not straight. Other factors also have a considerable influence on the deflection under load, namely, the form factor—a plate of rubber with a large area under load and small free surface will be stiffer in effect than in a case where, by cutting the plate into pieces, the free surface is increased; the effect of friction between surfaces of rubber and feet of item—the stiffness of a rubber mounting varies considerably between the extremes of well-vaselined smooth surfaces and rough machined ones but, though a bonded rubber-to-metal joint would have the advantage of constancy, it would lose the damping effect due to this friction; and the effect of dynamic loading on the frequency of rubber mountings—it is found that a rubber mounting, when acted on by a pulsating load, has a frequency that increases with the frequency of the load. As a result of these conflicting factors, it is only possible to specify an approximate area per ton supported for these mountings, based on experimental results.

The placing of a simple rubber pad under the holding-down bolts (between suitable metal washers) was an obvious means of lessening the decelerating forces on feet and holding-down arrangements. In many cases, this was all that was necessary to safeguard the machine, since in decelerating, the feet are usually the weakest part. The areas of rubber fitted are generally lower than that of the accelerating type of pad, as the maximum decelerating forces met with are usually lower than those in acceleration. Since no weight is taken on the washers, questions of creep and vibration do not normally arise, but the washers should not be screwed down unduly tightly when fitted.

Another method of limiting the decelerating force on the feet is the use of stretching lengths in the holding-down bolts, either in conjunction with decelerating washers or without them where a more rigid arrangement is required. The diameter of the stretching length should be sufficiently below the diameter at the bottom of the thread to ensure that notch effect does not cause fractures in the thread. The elongation of the stretching length will absorb a very considerable amount of energy before fracture occurs, besides making it simpler to design the feet so that fracture of the feet shall not occur. To ensure this, it is usual to allow a figure of 24 to 25 tons per square inch for the yield point of mild steel for bolts that are to yield, and 16 tons per square inch for feet that should not yield.

It has been known for some time that the rate of application of the load affects the yield point of a metal quite considerably. Since this is an important factor in cases such as those under discussion, investigations have been carried out to find the yield point at various rates of loading, and the principal results to date have been published in various technical papers. Further tests are envisaged in which not only the rate of application, but the duration of the load, is varied.

In view of the complex nature of the problem, it is clear that calculation alone cannot ensure a wholly satisfactory design, and some means of testing typical machines up to the design limit is necessary. Full-scale tests on ships are not satisfactory for this, since the vessels chosen and their machinery are normally obsolete; neither do more than one or two items get the full intensity of shock from a damaging shot. The ship trials do, however, give the necessary data on shock effects if some means can be found to reproduce these in a test shop.

Shock machines for testing electrical gear up to ½ ton in weight have been installed at the Admiralty Experimental Laboratory. These are of the swinging-hammer type, the intensity of shock being governed by the height that the hammer drops. This gives satisfactory results for the smaller items of gear and has enabled considerable investigation to be made into the movements of switchgear under shock, and very considerable improvements in design have resulted from its use. For the heavier machinery items, however, the problem is somewhat more difficult, but endeavours are being made to design a testing machine suitable for this purpose, on which typical machines could be tested out and the most economical shock resistant design worked out.

(To be continued.)

LIVERPOOL STREET-SHENFIELD ELECTRIFICATION.—A major stage in the electrification of the Eastern Region railway lines from Liverpool Street and Fenchurch Street stations to Shenfield is being undertaken between May 18 and 23. Prefabricated track and new signalling are being installed in certain areas at Liverpool Street station.

NOTES ON NEW BOOKS.

The Cathode Ray Oscillograph in Industry. By W. WILSON, D.Sc., M.I.E.E. Third edition. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 18s. net.]

SINCE the publication of the second edition of this excellent book less than two years ago, the main advances in cathode-ray oscillography having industrial applications have come from radiolocation research; consequently, the text has been appropriately modified on such subjects as fluorescent screens and the relative merits of electrostatic and magnetic beam deflection, while the principal modifications and developments of the cathode-ray tube itself are briefly described in a new appendix. These additions enhance the value of a competent survey embracing modern oscillographs and their associated circuits, the electron microscope, and a diversity of applications throughout engineering and physics. The author pays special attention to the use of oscillograph apparatus for experimental work on the characteristics of electronic equipment, the mechanical properties of engineering materials, and the performance of machinery and engines. Admirable writing and good illustrations are combined in a book which can be recommended to industrial technologists and research workers.

Skilled Hands. National Institute for the Blind, 224-228, Great Portland-street, London, W.1.

DURING the war a great deal of useful work was done in training totally-blind persons to carry out industrial operations, often of some complexity and involving considerable exercise of judgment. The results were notably successful and showed that, in peace-time work also, there were many more occupations for which sightless persons were suitable than had been generally assumed by industrial employers. The present brochure illustrates a variety of instances, many of them in the engineering industry, such as capstan-lathe and drilling-machine operation, instrument assembly, inspection by means of the Braille micrometer, and press-tool operation; as well as in general commercial and clerical employment. The National Institute, working in co-operation with the Ministry of Labour, maintain a staff of employment officers to advise employers on the engagement and training of blind persons, the lay-out of their work, etc. It is a fairly general experience, confirmed by evidence quoted in the brochure, that the output of blind persons, when they have acquired the necessary skill, is above the average of workmen having normal sight.

Engineering Tools and Processes. By PROFESSOR HERMAN C. HESSE. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 5.60 dols.); Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 28s. net.]

THIS excellent text-book of the practical processes used in engineering was first published in November, 1941. It covers a wide field and is most suited to the engineering student whose practical training is of limited duration, and who wishes to make the most of it by reading in compact form just enough about each operation he encounters in the shops to be able to place it in the general scheme of production technique. The author, indeed, claims that the book may serve as a substitute for the shop experience that is so essential to successful design, but without subscribing to the view that any book can be a substitute for practical experience, it may be accepted that, as a work of reference, it cannot fail to be of great help to anyone making his first contacts with workshop processes. The book concludes with some 30 pages of questions and problems, and the student who masters these will be well equipped for any examination on workshop practice. As is so often the case with American publications, it is a matter for regret by the English reader that the standards referred to and the bibliographies given are almost entirely American, but these are not used, as is sometimes the case, to pad out the text. The book may be commended to the student who has not had the benefit of a long apprenticeship.

Materials Handbook. By GEORGE S. BRADY. Sixth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7 dols.]; McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 42s.]

THE handbook bears the sub-title "An Encyclopedia for Purchasing Agents, Engineers, Executives, and Foremen," and the materials are dealt with, in the manner of an encyclopædia, by short authoritative articles arranged alphabetically under their names, commencing with "Abrasives" and ending with "Zirconium-ferrosilicon." At the end there are some short general articles on physical and geological aspects of materials, with maps, and a number of useful tables of physical and statistical data. The general usefulness of such a compilation is obvious, provided the information given is adequate; and it is not necessary to sample more than a few individual articles to discover that the book is a model of how to impart the maximum information in the minimum number of words. The style throughout is delightful for its conciseness and directness, as countless users must have discovered already, since the handbook was first published in 1929. Since then it has been greatly extended, particularly in recent years, as the result of the author's experience as chief materials consultant to the Office of Civilian Supply and to the United States Board of Economic Warfare, until it has become a most valuable work of reference.

The Locomotives of the Southern Region of British Railways. Compiled and published by W. G. Tilling, 106, Great Dover-street, London, S.E.1. [Price 5s.]

IN previous years, the author has published several books on the locomotives of the principal companies that were amalgamated to form the Southern Railway, which is now the Southern Region, namely, the London Brighton and South Coast, the London and South Western, and the South Eastern and Chatham Railway Companies. His latest book embraces the whole system. A brief description of the railway is given, showing the areas served, the extent of electrification, the types of traffic, the organisation in sections, and some of the principal alterations and improvements carried out in recent years. The locomotives are grouped under the names of the designers: Stroudley, Kirtley, Adams, Stirling, R. J. Billington and L. B. Billington, Drummond, Wainwright, Marsh, Urie, Maunsell and Bulleid. Although some information on the design of each class of engine is given, Mr. Tilling has devoted more space to an account of the type of work for which they are, or were, used. The book contains numerous photographic illustrations, tables showing the number, class, wheel arrangement, year and place of construction and name of all the locomotives, and tables of the principal dimensions, etc., of each class.

The Law of Trade Unions. By H. SAMUELS, M.A. Third edition. Stevens and Sons, Limited, 119-120, Chancery-lane, London, W.C.2. [Price 6s. net.]

THE first appearance of this excellent manual, in the early part of 1946, practically coincided with the repeal of the Trades Disputes Act of 1927 and, in consequence, a second edition was required almost immediately so as to take account of the changes thus introduced. This was done by the addition of an appendix showing the effect of the repealing Act. The present edition follows generally the same plan, with some further revision, and well achieves its stated object, namely, "to present in brief compass an account of this branch of law as it now stands after the repeal of the 1927 Act. It may be thoroughly recommended as a succinct compendium of the various Acts and leading cases in this somewhat highly specialised field.

Coal Mining in Australia. By HAROLD S. ELFORD, B.E., and MAURICE R. MCKEOWN, M.Aust.I.M.M. Tait Publishing Company Pty. Limited, 349, Collins-street, Melbourne, C.1. [Price 15s.]

THIS comprehensive survey of the technical aspects of coal mining in Australia includes details of the geographic and geological distribution of the coal deposits, mining methods, use of mechanical equipment, preparation of coal for the market, and the factors relating to safety and health. Almost all of the coal obtained from Western Australia and Queensland is mined by hand; it is only in New South Wales that mechanical equipment is being used to any extent. As the output for the whole of Australia is about 14,000,000 tons a year, or 1,000,000 tons below the present demand, the authors rightly stress the importance of introducing mechanical coal cutters, electrically-operated boring machines, power loaders and conveyors, with a view to increasing output. All phases of mechanisation are described concisely, and the vital questions of costs and the problems of installing modern equipment in an old mine are not overlooked. The second part of the book is devoted to statistics and factual descriptions of operations at 14 mines in New South Wales and 11 mines located in the other coal-producing areas of Australia. References to many geological bulletins, reports and technical papers are listed in the bibliographies at the end of the chapters, and a glossary of mining terms is given as an appendix. The authors have included a considerable amount of technical data in this 250-page "conducted tour" of the coal mines of Australia, and, with the aid of 197 excellent reproductions of photographs and diagrams, have succeeded in presenting the information in a manner which will be readily understood by those not connected with the mining industry.

LAUNCHES AND TRIAL TRIPS.

S.S. "PARTHIA."—Twin-screw liner with accommodation for 250 passengers in one class, together with insulated and general cargoes. Built and engined by Messrs. Harland and Wolff, Limited, Queen's Island, Belfast, to the order of the Cunard White Star Limited, Cunard Building, Liverpool, 3, for North Atlantic service. Main dimensions: 531 ft. 5 in. by 70 ft. by 33 ft.; load draught, 30 ft. 2½ in.; gross tonnage, about 13,340. Two sets of turbines designed in collaboration with Messrs. Parsons Marine Steam Turbine Company, Limited, Turbinia Works, Wallsend-on-Tyne, with double-helical double-reduction type gearing, developing about 13,700 shaft horse-power and a speed of 17 knots, in service. Trial trip, March 31 to April 2. Maiden voyage, April 10.

S.S. "VIKTUN."—Single-screw vessel for the carriage of oil in bulk and other cargoes. Built by Messrs. John Readhead and Sons, Limited, West Docks, South Shields, to the order of the Tanker Corporation, Panama City. Main dimensions: 405 ft. 10 in. by 60 ft. by 37 ft. 6 in.; deadweight capacity, about 8,000 tons on a draught of 24 ft. approximately. Fredriksstad double compound steam motor, built under licence by Messrs. John Readhead, with two Foster Wheeler water-tube boilers built by Messrs. Richardsons, Westgarth and Company, Limited, West Hartlepool, Wallsend-on-Tyne, giving a maximum speed of 13 knots. Trial trip, April 28.

S.S. "BESSEGGEN."—Single-screw cargo vessel, built by Messrs. William Gray and Company, Limited, West Hartlepool, to the order of the Rederiet Besseggen A/S (Mr. Chr. Østberg), Radhusgt. 17, Oslo. Main dimensions: 336 ft. by 47 ft. by 27 ft. 10½ in. to shelter deck; deadweight capacity, 3,500 tons on a loaded draught of 19 ft. summer freeboard. Triple-expansion reciprocating engine supplied by Messrs. George Clark (1938), Limited, Southwick Engine Works, Sunderland, developing 1,900 indicated horse-power, with a loaded speed of over 12 knots. Trial trip, April 28.

M.S. "INTERPRETER."—Single-screw cargo vessel, with accommodation for eight passengers, built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, for Messrs. Thos. and Jas. Harrison, Mersey Chambers, Liverpool, 2. Main dimensions: 460 ft. 3 in. by 60 ft. by 32 ft. 3 in.; deadweight capacity, about 9,270 tons. Doxford opposed-piston five-cylinder oil engine to give a service speed of 14 knots; a mean speed of 15¼ knots being attained on the measured mile. Trial trip, April 28.

S.S. "DUQUESA."—Single-screw vessel for the carriage of meat, fruit, dairy produce, mails and twelve passengers, built by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn Shipbuilding Yard, Hebburn-on-Tyne, for the United Kingdom/Spain and River Plate trade of Messrs. Furness-Houlder Argentine Lines, Limited, 53, Leadenhall-street, London, E.C.3. Main dimensions: 479 ft. 6 in. by 65 ft. 6 in. by 37 ft. 10 in. to shelter deck; insulated cargo capacity, about 560,000 cub. ft. Double-reduction geared turbines, producing 6,800 shaft horse-power giving a speed of 15 knots in service. Launch, May 10.

M.S. "HUNTINGDON."—Twin-screw refrigerated and general cargo vessel, built and engined by Messrs. Alexander Stephen and Sons, Limited, Linthouse, Glasgow, S.W.1, for the Federal Steam Navigation Company, Limited, London. Main dimensions: 561 ft. by 70 ft. by 47 ft. 6 in.; deadweight capacity, 14,300 tons on a draught of 32 ft. 6 in. Two Stephen-Doxford Diesel engines developing 12,800 brake horse-power, and giving a speed of 17 knots. Trial trip, May 11 and 12.

"BRITISH EXPORTS AND EXCHANGE RESTRICTIONS ABROAD."—The Swiss Bank Corporation, 99, Gresham-street, London, E.C.2, have published a second edition of their brochure entitled "British Exports and Exchange Restrictions Abroad." In this are set out in a concise manner the regulations existing in the various countries of the world, in so far as they affect exports from the United Kingdom. The information given is clear and the publication should prove useful to merchants and exporters.

SUMMER SCHOOL IN RELAXATION METHODS.—In the long vacation of the past three years, summer schools in "Relaxation Methods" have been held at the Imperial College of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Their success has encouraged the provision of a similar course in the coming long vacation, and this will be held in the four weeks July 6 to 30. It is proposed to concentrate on questions involving partial differential equations in two independent variables. The course will consist of lectures on Tuesdays and Fridays, with numerous examples to be solved under supervision on other days. Particulars of fees, and other information, may be obtained from Mr. D. N. de G. Allen, Imperial College, at the address given above.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

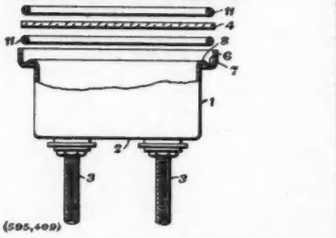
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

595,409. Instrument Casing. Elliott Brothers (London) Limited, and L. W. Pettitt, both of Lewisham, Kent. (2 *Figs.*) October 19, 1944.—This invention discloses a method of hermetically sealing the cases of electrical measuring instruments having a transparent window, usually of glass. The casing consists of a one-piece cylindrical part 1 having a closed rear end 2 with apertures for terminal posts 3, which are hermetically sealed in place in any usual manner, a front cover 4 of glass for permitting inspection of the instrument dial and an annular bezel 5 for securing the glass cover in place. The parts 1, 2 and 5 are formed from thin sheet metal. The mouth of the cylindrical part 1 is enlarged to provide a circumferential seating surface 6 bounded at its outer edge by a cylindrical wall 7, the seating surface 6 being of semi-circular cross-section and connected with the smaller diameter cylindrical wall 1 by a convex portion 8. The bezel 5 has a cylindrical wall, the internal diameter of which is very slightly larger than the external diameter of the wall 7 on the main casing and is connected at its upper end by an inwardly extending



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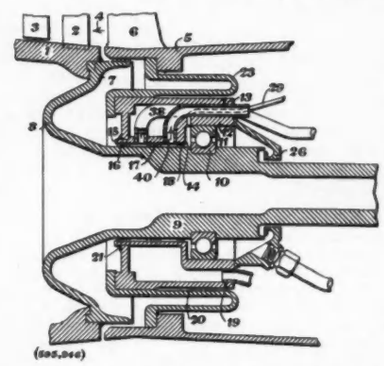
annulus 9 of width of the order of the thickness of the metal, to an annular seating surface 10, which is semi-circular in cross-section. The glass cover 4 is circular and of a diameter slightly less than the internal diameter of the wall 7 on the main casing. Rubber sealing rings 11 of circular cross-section fit into each of the seating surfaces 6 and 10. The cylindrical wall of the bezel 5 is of somewhat greater axial length than the wall 7 on the main casing, but the last-mentioned wall is of such axial length that its free edge will be spaced by a predetermined amount from the annulus 9 on the bezel when the parts are loosely assembled preparatory to effecting connection between them. Thus when the sealing rings 11 have been laid on their respective seating surfaces 6 and 10, the glass cover 4 has been laid on the lower sealing ring 11 and the bezel 5 has been pressed over the wall 7 on the main casing until the upper sealing ring 11 bears on the glass cover 4, the free edge of the wall 7 is spaced from the annulus 9 of the bezel 5 and the free marginal portion 5*a* of the wall on the latter projects below the seating 6 on the main casing. The case is sealed by placing the assembled parts in a press which forces them together axially and then deforms the projecting marginal portion 5*a* of the bezel wall inwards and upwards into close contact with the bottom of the seating 6 on the main casing. (*Sealed.*)

INTERNAL-COMBUSTION ENGINES.

595,346. Gas-Turbine Bearing. Metropolitan-Vickers Electrical Company, Limited, of London, H. Constant, of South Farnborough, Hants, D. M. Smith, of Manchester, and F. E. Baumann, of Wilmslow, Chester. (1 *Fig.*) May 7, 1941.—This invention consists of a housing for a ball or roller bearing as used in a gas turbine, constructed so as to be proof against the entry of gas from either side and to permit lubrication and cooling. A small part of the drum of the turbine is indicated at 1, and 2 is a part of the first row of blading carried by the drum 1. At 3 is shown a part of a row of fixed blading carried by a stator casing (not shown). The direction of gas flow is indicated by the arrow 4, and 5 is a part of the inner wall of the discharge passage from the annular internal-combustion chamber (not shown). At 6 is shown part of a radial supporting web uniting the left-hand end of the passage wall 5 with the exterior casing of the machine. The rotor cylinder 1 is welded at 7 to a "swan-neck" disc 8 integral with the hollow shaft 9 on which is carried the inner race 10 of the ball bearing. The outer race 11 is carred by a sleeve 12 having at the right-hand end an external flange 13. The sleeve 12 is reduced in diameter at 14 and is connected to a sleeve 15 which surrounds the left-hand end of the shaft 9 with relatively small clearances, while three sets of labyrinth packing, 16, 17 and 18,



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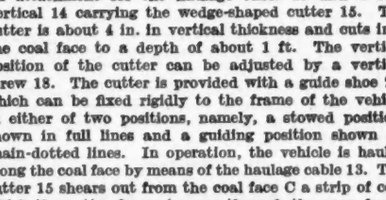
are provided. The flange 13 of the sleeve 12 is welded at 19 to the right-hand end of an outer sleeve 20, the left-hand end of which has an internal flange welded at 21 to the left-hand end 15 of the bearing sleeve 12. The left-hand end of the sleeve 20 is bolted to an internal flange on the left-hand end of a "swan-neck" member 23. The member 23 provides flexibility. The outer race of the ball bearing is thus supported from the wall member 5. An annular cover 26 is secured to the right-hand end of the sleeve member 12 which, along with its portion 14 and with the member 26 provides the housing for the bearing. A pipe 29 conveys air and oil mist into the bearing housing for lubrication purposes. The pipe 38 is connected to a source of cooling air and a pipe 40 leads from the space between the sets of packing 17 and 18 to atmosphere. (*Sealed.*)

MINING.

594,750. Mining Apparatus. Mavor and Coulson, Limited, of Glasgow, and J. B. Mavor, of Glasgow. (9 *Figs.*) July 2, 1945.—This invention is a machine for stripping coal from the face of a seam. It consists of an open-frame vehicle to be hauled along the mine floor, the frame having a top longitudinal member to co-operate with the mine roof and a bottom longitudinal member to run on the floor, and one or more wedge-shaped cutters mounted on the frame for stripping the coal and forcing it laterally between the longitudinal members so that it passes through the open frame. The vehicle is hauled by a cable operated by a winch in a stationary position. The vehicle, shown in plan, consists of an open rectangular frame formed by a lower longitudinal arranged to slide upon the mine floor; an upper longitudinal 11 that, in case of need, will slide against the mine roof, a front vertical 12 provided with



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an attachment for the haulage cable 13 and a rear vertical 14 carrying the wedge-shaped cutter 15. The cutter is about 4 in. in vertical thickness and cuts into the coal face to a depth of about 1 ft. The vertical position of the cutter can be adjusted by a vertical screw 18. The cutter is provided with a guide shoe 20, which can be fixed rigidly to the frame of the vehicle in either of two positions, namely, a stowed position, shown in full lines and a guiding position shown by chain-dotted lines. In operation, the vehicle is hauled along the coal face by means of the haulage cable 13. The cutter 15 shears out from the coal face C a strip of coal which the cutter forces to pass through the open frame of the vehicle to the conveyor 21. The coal is guided to the conveyor by the baffle plate 26 above and the retaining plate 23 below. As the vehicle works along the coal face, the roof-supporting props 24, acting upon the rail 25, hold the vehicle against the coal face. (*Sealed.*)